

# AIRS Land Surface Temperature and Infrared Emissivity Validation

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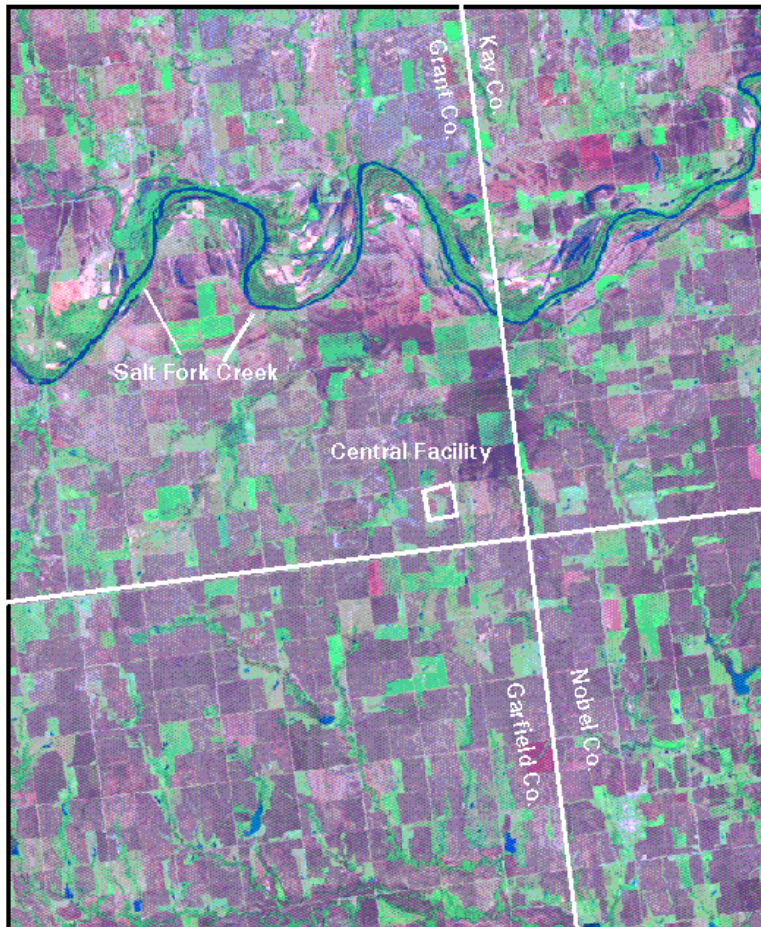
# Topics

- [PGE Version 4](#) – Temperature Validation  
(Example from fixed site.)
- [PGE Version 5](#) – Early look at Emissivity  
(Examples from Lihang Zhou/Chris Barnett)
- [PGE Version 6](#) – Recommendations for a  
new approach to modifying and validating  
algorithm changes.

# AIRS Land Surface Temperature Validation

PGE Version 4

# AIRS Temperature Validation: Ground Truth



Landsat TM Scene 28/35

Scene date: 970927

Bands 7,4,2



Red, Purple: Cropland

Lt. Green: Pasture, Grass, etc.

Dark Green: Trees, shrubs, etc.

Blue: Water

Landsat TM scene provided by R. Cahalan, NASA-Goddard

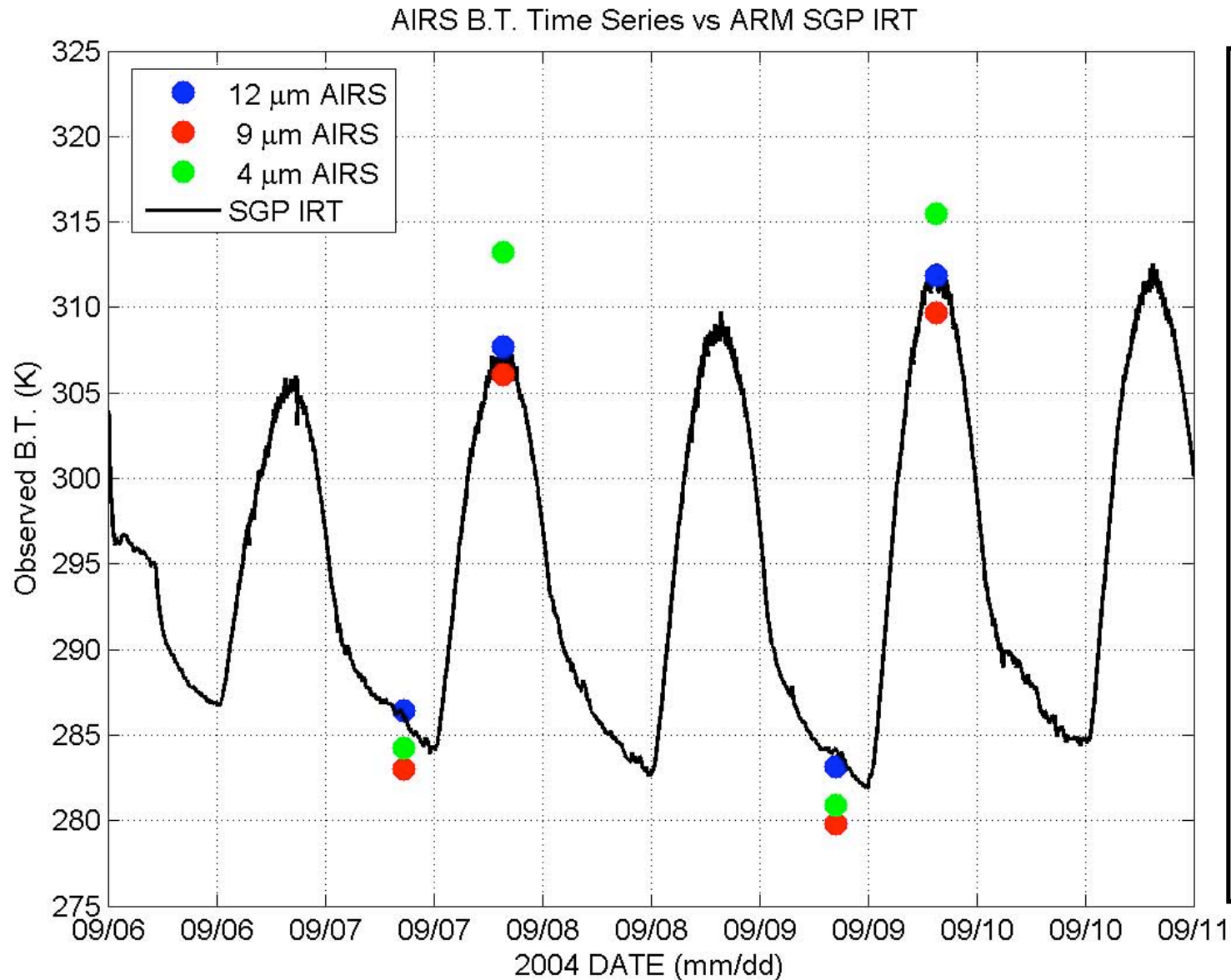
Map by Alice Cialella 2/05/98

## ARM SGP Site

- Mid-Continental (Oklahoma)
- Provides **surface and atmospheric** profiling measurement accuracy
- Long-term **continuous** observations are ideal for comprehensive satellite validation



# AIRS Temperature Validation: Ground Truth



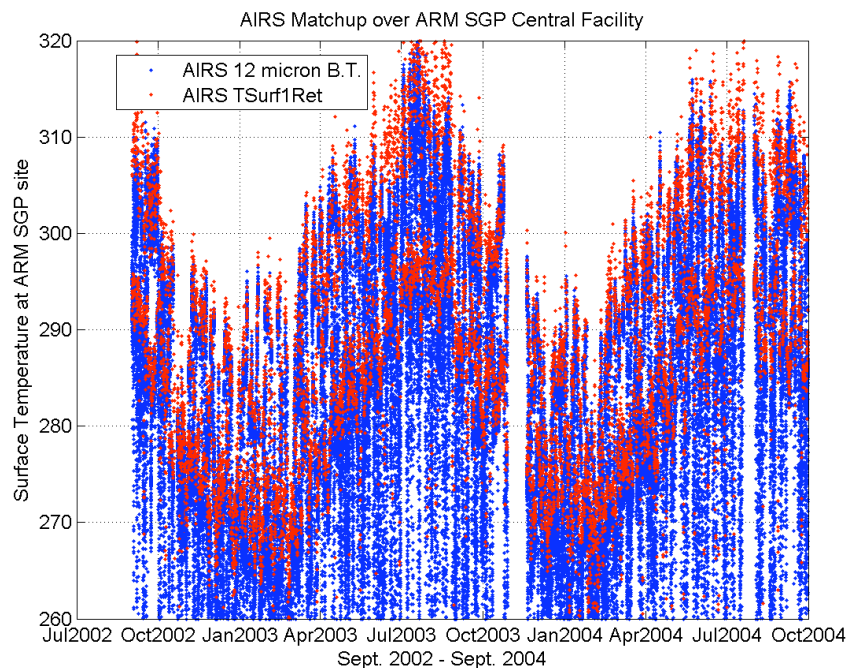
## Comments

Coincident  
with  
**Dave  
Tobin's**  
AIRS/  
ARM  
Best  
Estimate  
Profiles



AIRS PGE Version 4  
DOE ARM SGP IRT  
(25 meter Tower)

01-Jun-2003 → 30-Apr-2006  
(1064 days: 1894 overpasses)



QFLAG = 0 ( $\ll$  1% of cases)

Statistics for Errors of  $\pm 10$  K:

FIRST GUESS (REGRESSION)

RETRIEVAL STATS:

night\_number: 4

night\_mean\_error: -1.3835

night\_median\_error: -1.3956

night\_std\_error: 0.2574

day\_number: 5

day\_mean\_error: 0.1437

day\_median\_error: 0.9011

day\_std\_error: 1.3698

FINAL RETRIEVAL STATS:

night\_number: 5

night\_mean\_error: -1.6918

night\_median\_error: -1.9234

night\_std\_error: 0.6680

day\_number: 5

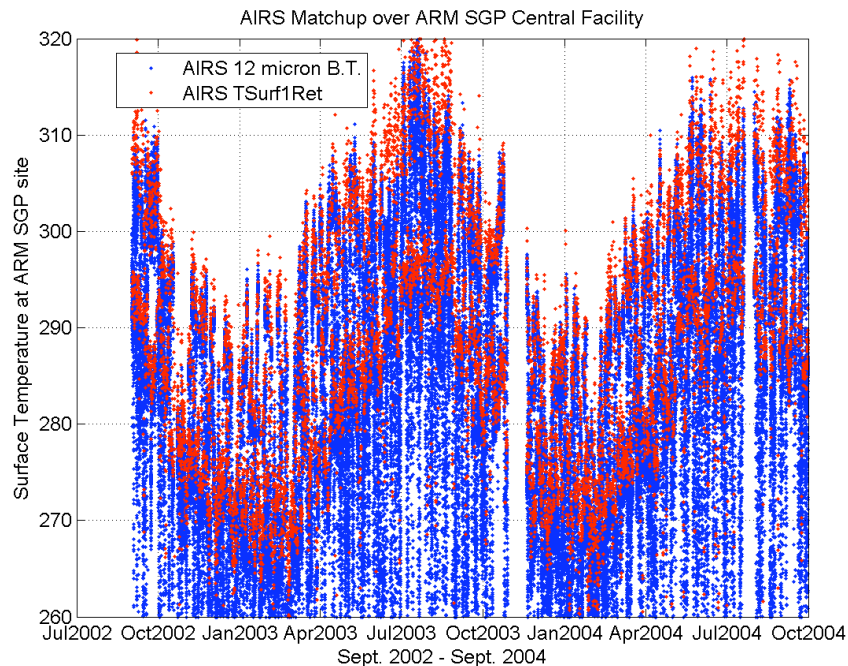
day\_mean\_error: 0.6457

day\_median\_error: 0.3342

day\_std\_error: 1.0984

AIRS PGE Version 4  
DOE ARM SGP IRT  
(25 meter Tower)

01-Jun-2003 → 30-Apr-2006  
(1064 days: 1894 overpasses)



QFLAG = 1 (~60% of cases)

Statistics for Errors of +/- 10 K:

FIRST GUESS (REGRESSION)

RETRIEVAL STATS:

night\_number: 586

night\_mean\_error: -0.4859

night\_median\_error: -0.3824

night\_std\_error: 1.8317

day\_number: 592

day\_mean\_error: -0.8960

day\_median\_error: -0.4558

day\_std\_error: 3.5081

FINAL RETRIEVAL STATS:

night\_number: 592

night\_mean\_error: -1.5998

night\_median\_error: -1.5407

night\_std\_error: 1.9080

day\_number: 601

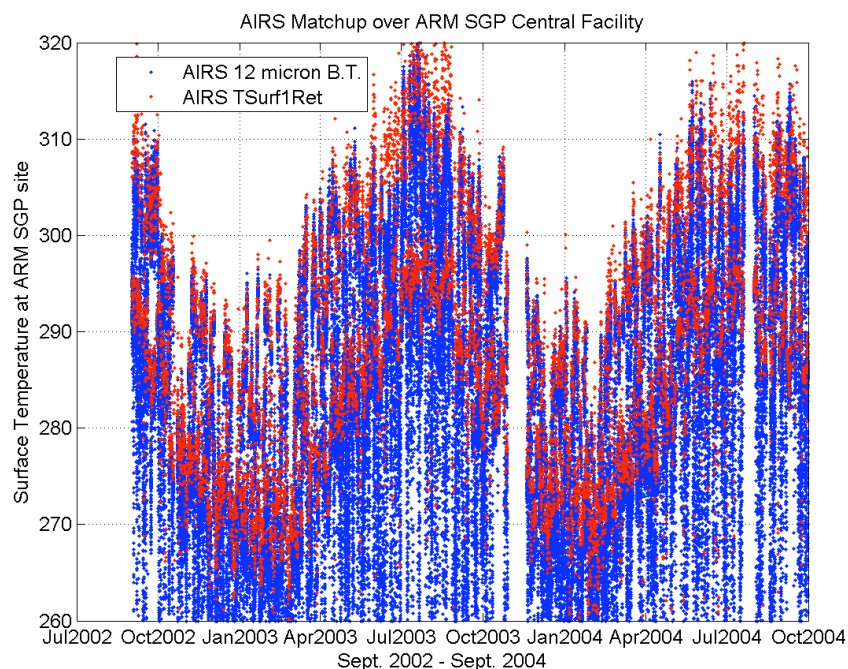
day\_mean\_error: -0.4015

day\_median\_error: -0.0083

day\_std\_error: 3.1743

AIRS PGE Version 4  
DOE ARM SGP IRT  
(25 meter Tower)

01-Jun-2003 → 30-Apr-2006  
(1064 days: 1894 overpasses)



$$\boxed{QFLAG = 2}$$

Statistics for Errors of  $\pm 10$  K:

FIRST GUESS (REGRESSION)

RETRIEVAL STATS:

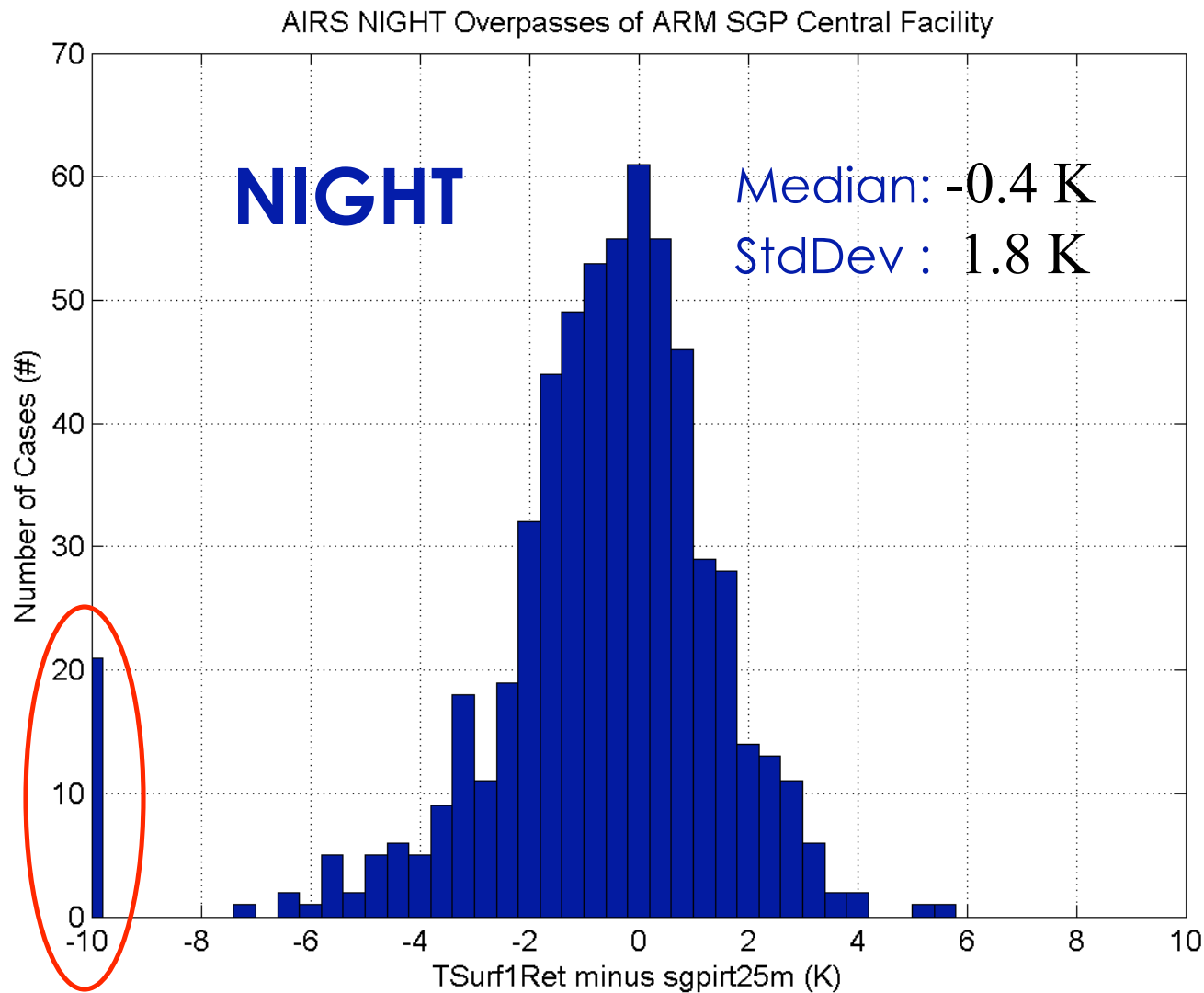
night\_number: 865  
night\_mean\_error: -0.8244  
night\_median\_error: -0.5024  
night\_std\_error: 2.5089  
day\_number: 813  
day\_mean\_error: -1.1001  
day\_median\_error: -0.6096  
day\_std\_error: 3.7840

FINAL RETRIEVAL STATS:

night\_number: 813  
night\_mean\_error: -1.1054  
night\_median\_error: -1.3853  
night\_std\_error: 2.8953  
day\_number: 870  
day\_mean\_error: -0.3963  
day\_median\_error: -0.0107  
day\_std\_error: 3.3179

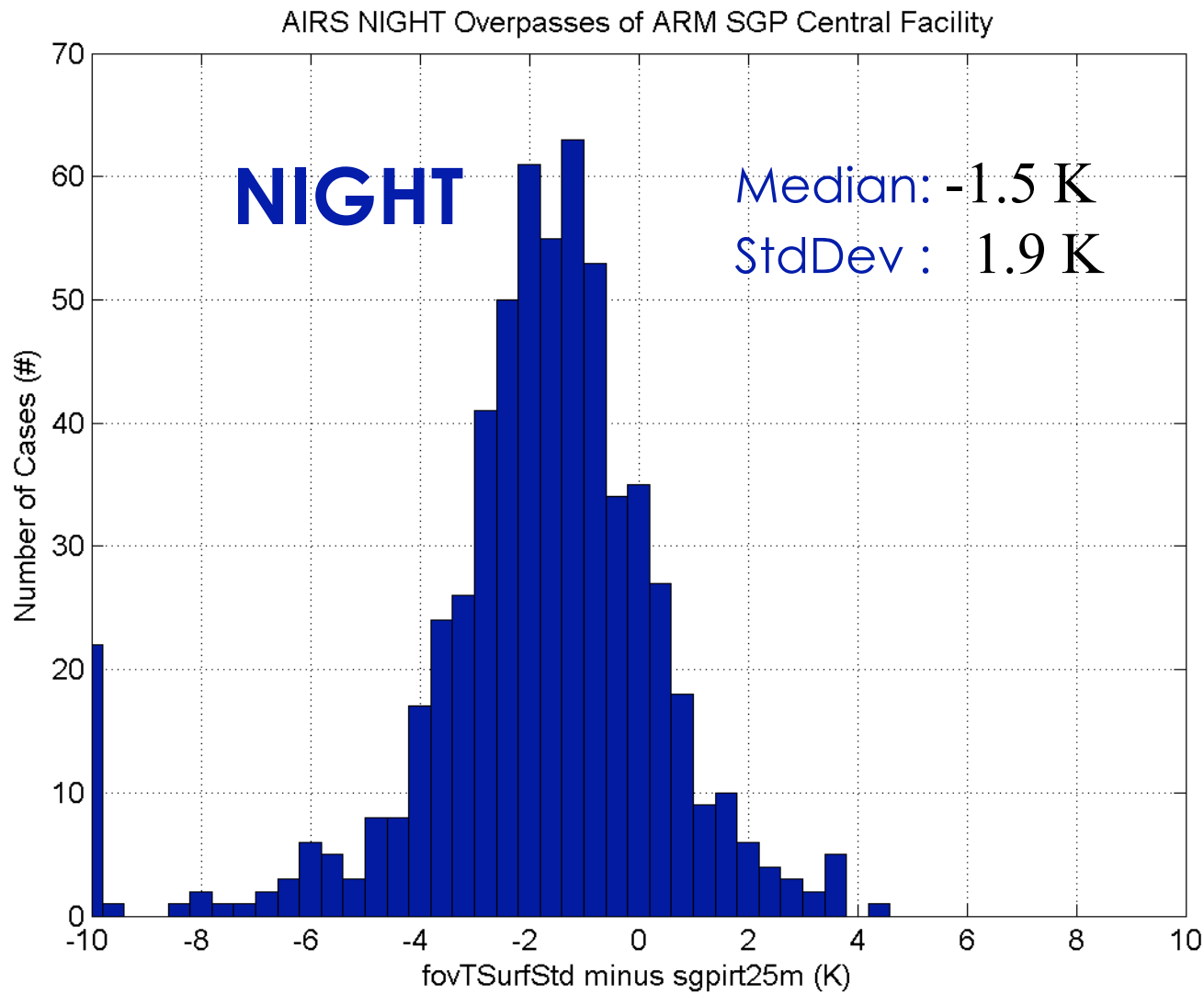


# First Guess (Regression) Retrieval



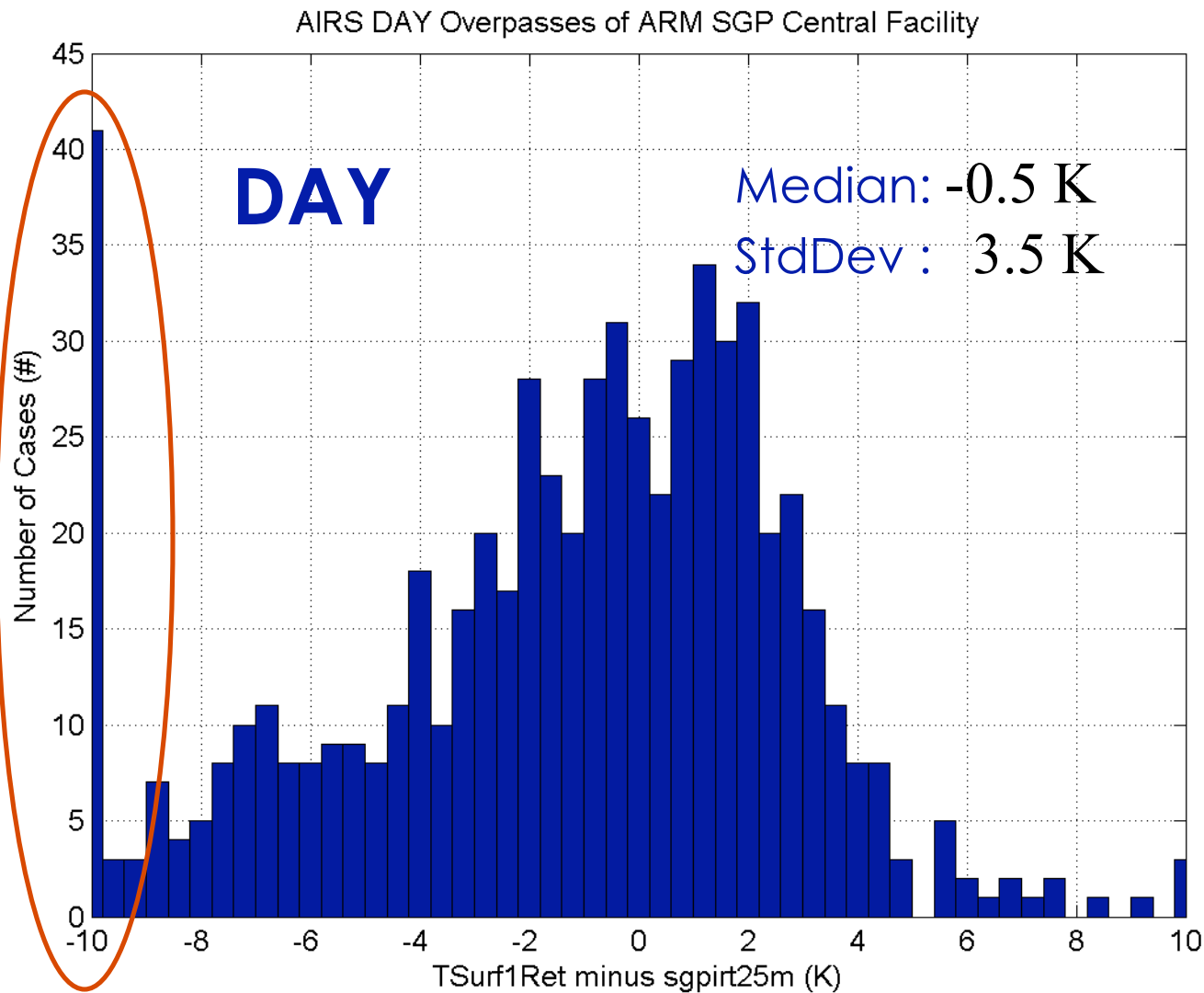
PGE Version 4; QFLAG = 1 (586 cases)

# Final (Physical) Retrieval



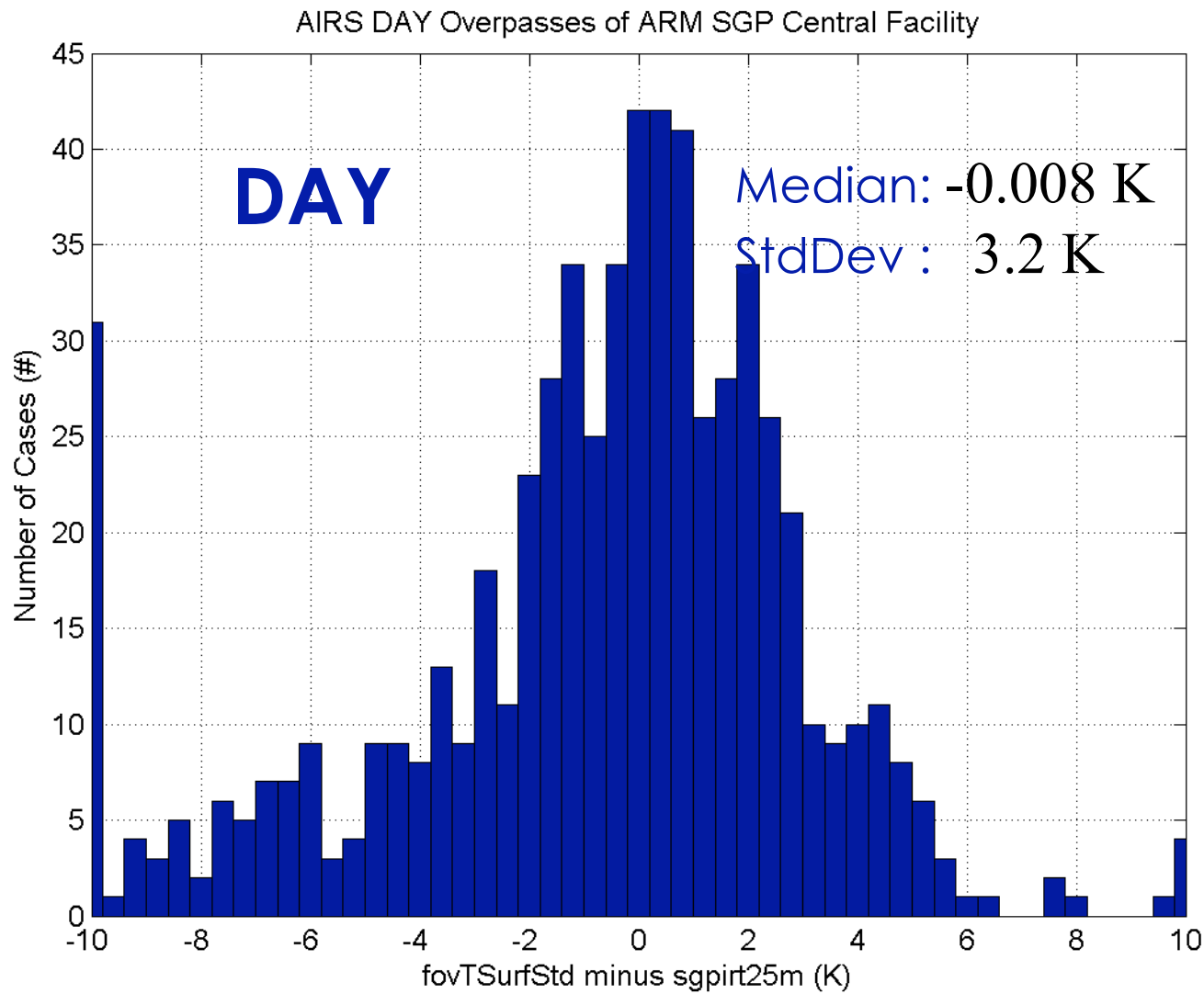
PGE Version 4; QFLAG = 1 (592 cases)

# First Guess (Regression) Retrieval



PGE Version 4; QFLAG = 1 (592 cases)

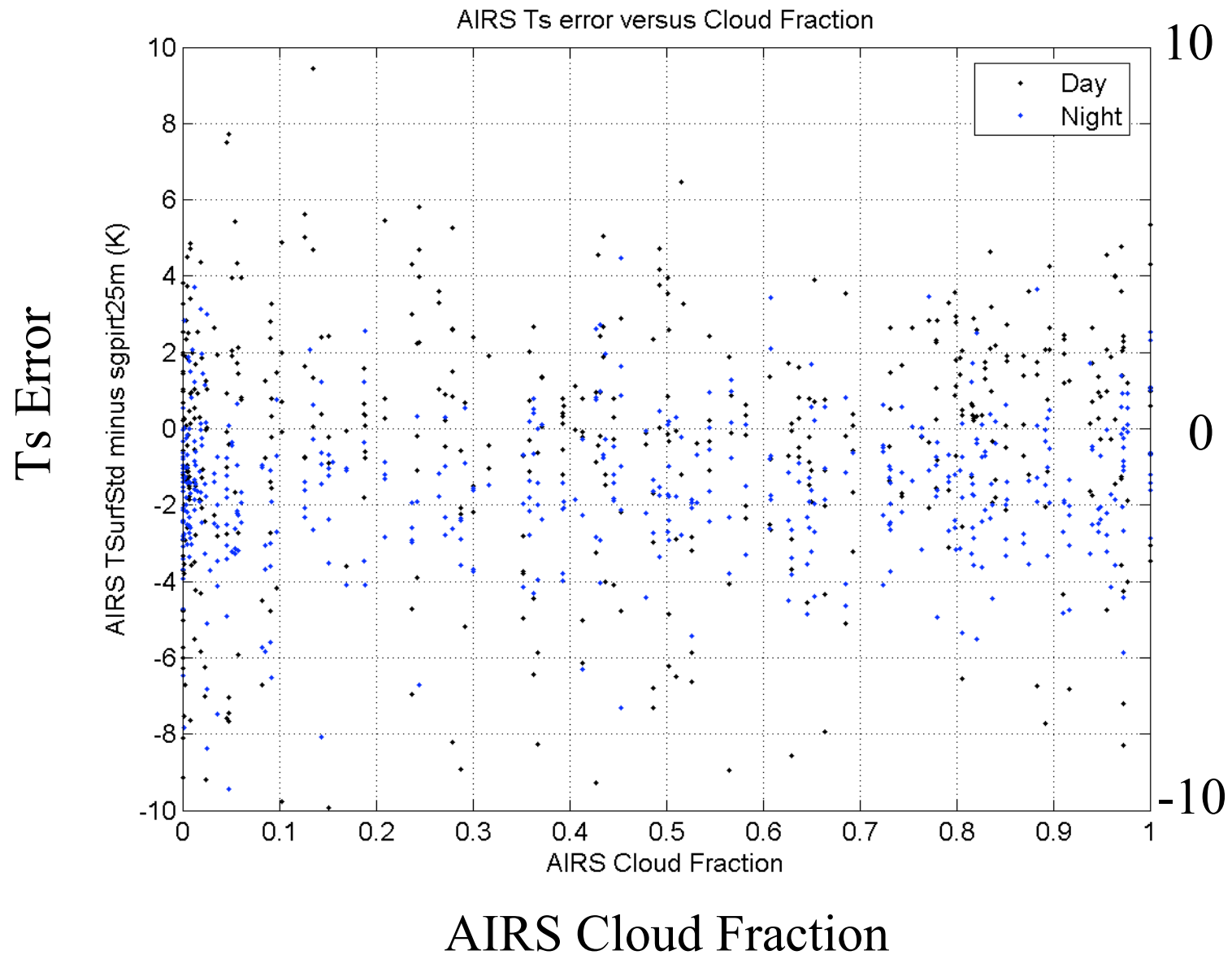
# Final (Physical) Retrieval



PGE Version 4; QFLAG = 1 (601 cases)



# Error Does NOT have any Cloud Fraction Dependence!



## PGE Version 4 Conclusion

- Temperature statistics were reasonably Gaussian after final physical retrieval, HOWEVER
- Final Retrieval has a 1 degree bias at night, and
- A significant number of outliers ( $> 5$  degree  $T_{\text{skin}}$  differences) are getting through the Quality Control.
- Evaluate the ARM retrieval temperature and water vapor statistics for the subset of the retrievals which agree with the surface temperature observations. This should help us understand the relation between retrieved  $T_s$  and Emissivity and the retrieval error of air temperature and water vapor profiles. (Tobin & I)

# AIRS Land Surface Infrared Emissivity Validation

PGE Version 5

Recent results from  
Lihang Zhou/Chris Barnet  
(Does not yet include Joel Susskind's results.)

# Details

- Lihang Zhou/Chris Barnet emissivity files were downloaded from ftp site on Aug.17, 2006 (emis\_noaa.tar)
- Seeman/Borbas' from global\_emis\_cdf2, dated July 26, 2006 – derived from MOD11C (AQUA collection 5).
- Details of MODIS-derived database are in Seeman, et al., 2006 (Submitted to JAM)



# What has been done so far?

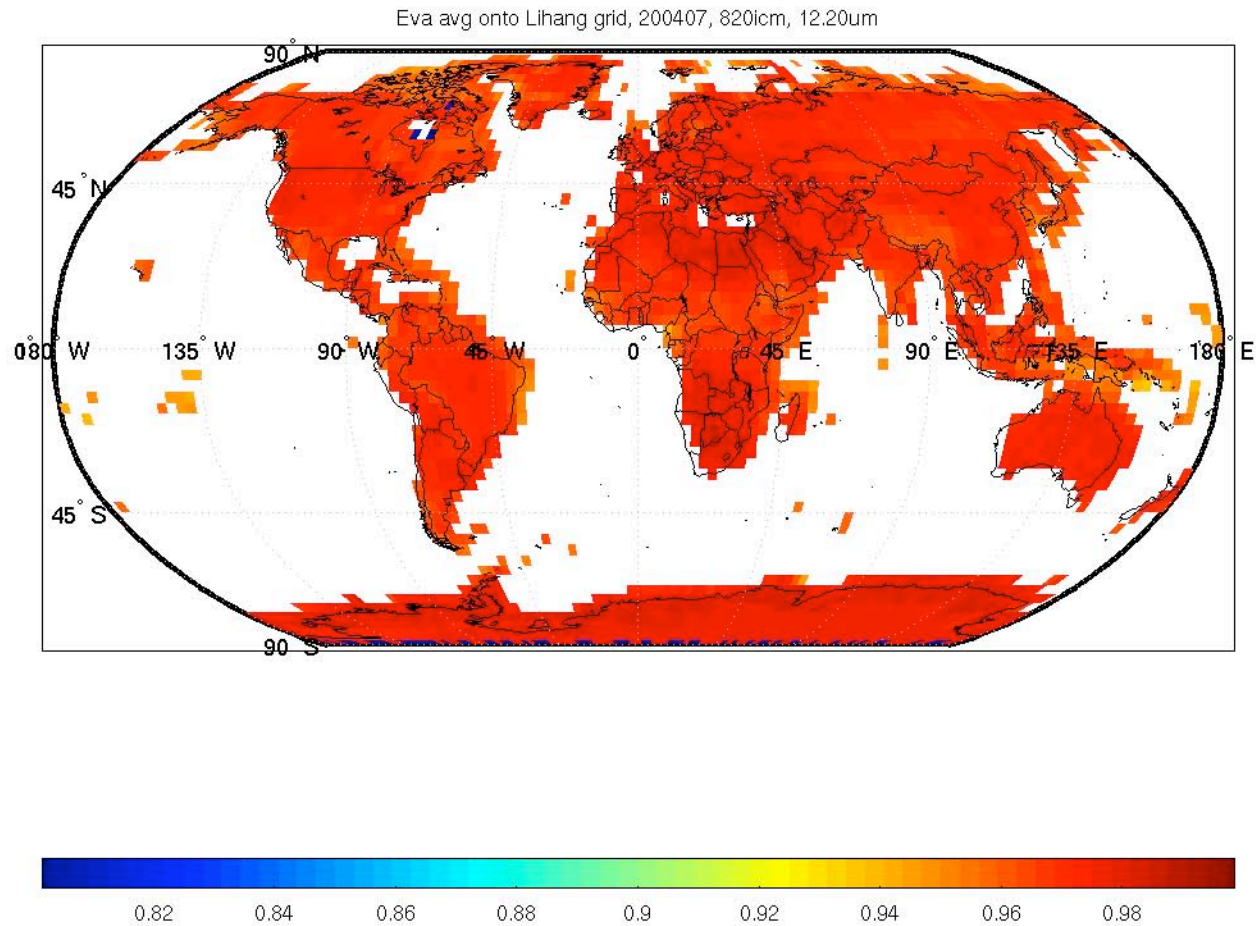
- Monthly averaged emissivities for 2004 July were compared globally at 42 wavelengths.
- Interpolated S&B emissivities onto Lihang's 42 wavelengths (ranging from 3.7 to 15.4  $\mu\text{m}$ )
- Averaged S&B values that fell inside of Lihang's grid boxes (S&B's gridding is 7200x3600, Lihang's is 120x61)
- Three wavelengths (4.34, 8.47, 12.2  $\mu\text{m}$ ) are shown
- For each wavelength there are 10 plots:
  - Map of Lihang's "Fg" emissivity
  - Map of Lihang's "Ret" emissivity
  - Map of Lihang's difference (Lihang\_ret-Lihang\_fg)
  - Map of S&B's emissivity
  - Map of their difference (Lihang\_fg-SB)
  - Map of their difference (Lihang\_ret-SB)
  - Map of the ratio of their difference (Lihang\_fg-SB)/SB
  - Map of the ratio of their difference (Lihang\_ret-SB)/SB
  - Histogram of the emissivity values (w/ Lihang\_fg)
  - Histogram of the emissivity values (w/ Lihang\_fg)

# Comparison was made at

- $12.2\ \mu\text{m}$  ( $820\ \text{cm}^{-1}$ )
- $8.5\ \mu\text{m}$  ( $1180\ \text{cm}^{-1}$ )
- $4.3\ \mu\text{m}$  ( $2300\ \text{cm}^{-1}$ )

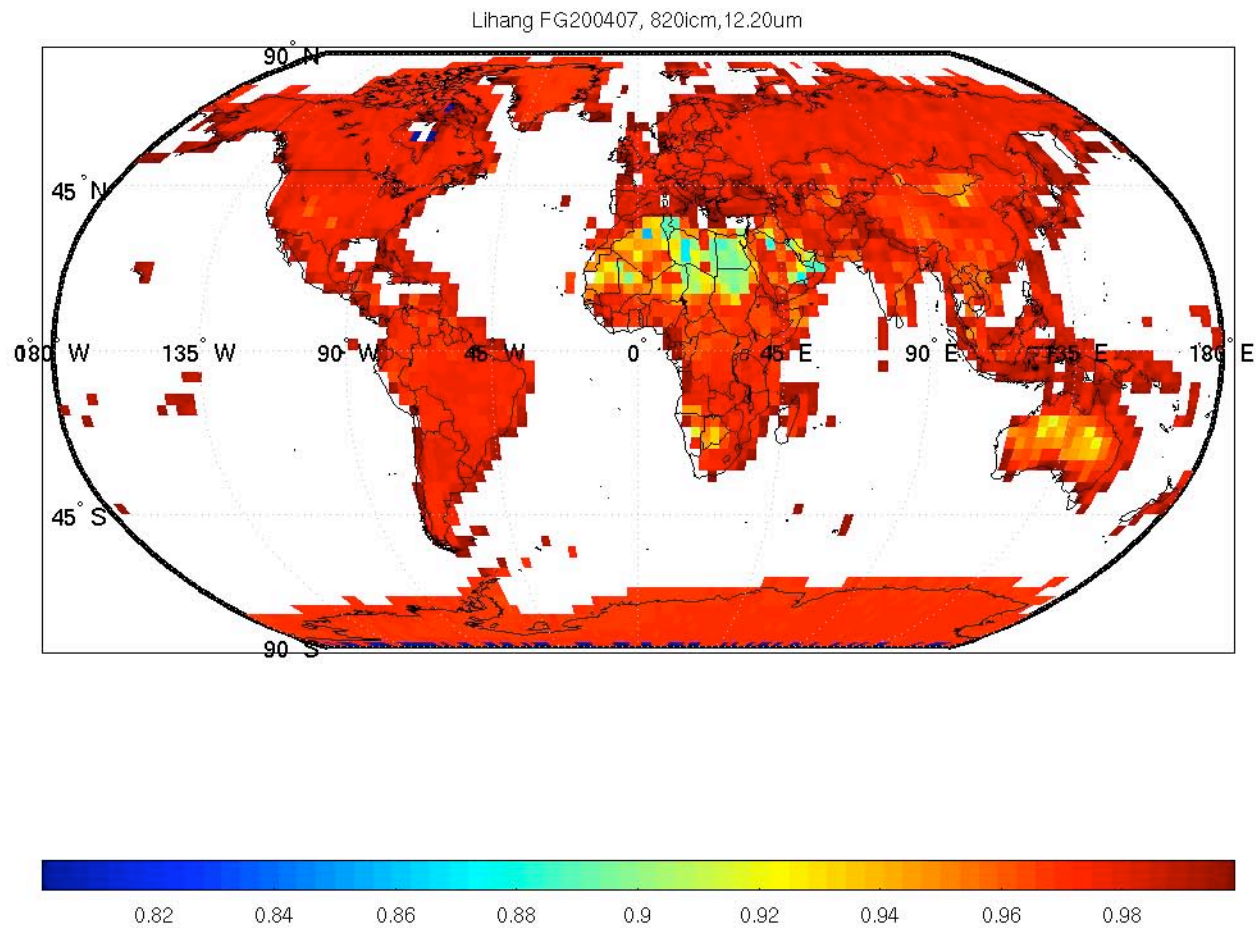
# UW/MODIS (Seeman/Borbias/Wan)

## $12.2\text{ }\mu\text{m}$ ( $820\text{ cm}^{-1}$ )



# Lihang Regression Retrieval

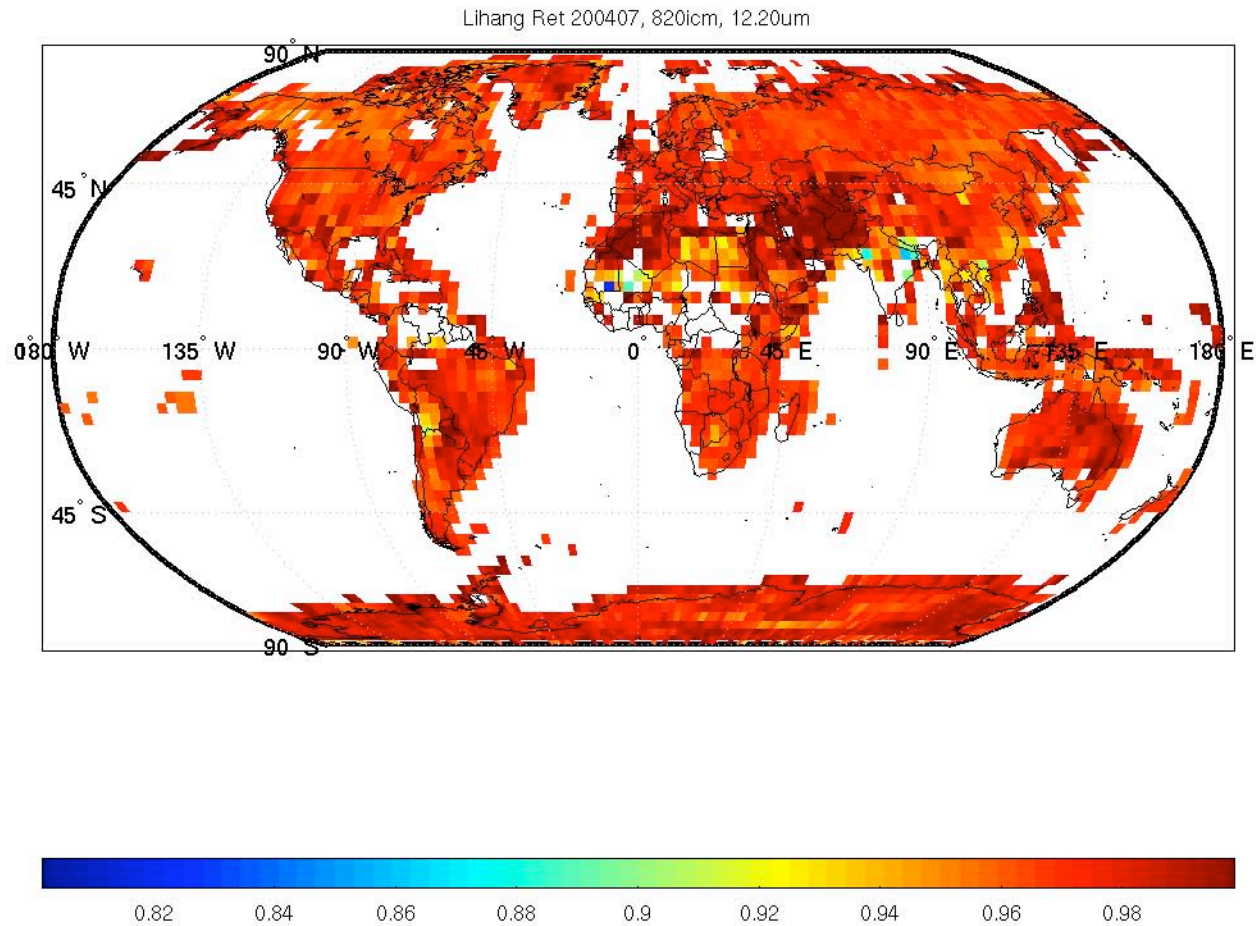
## $12.2\text{ }\mu\text{m}$ ( $820\text{ cm}^{-1}$ )



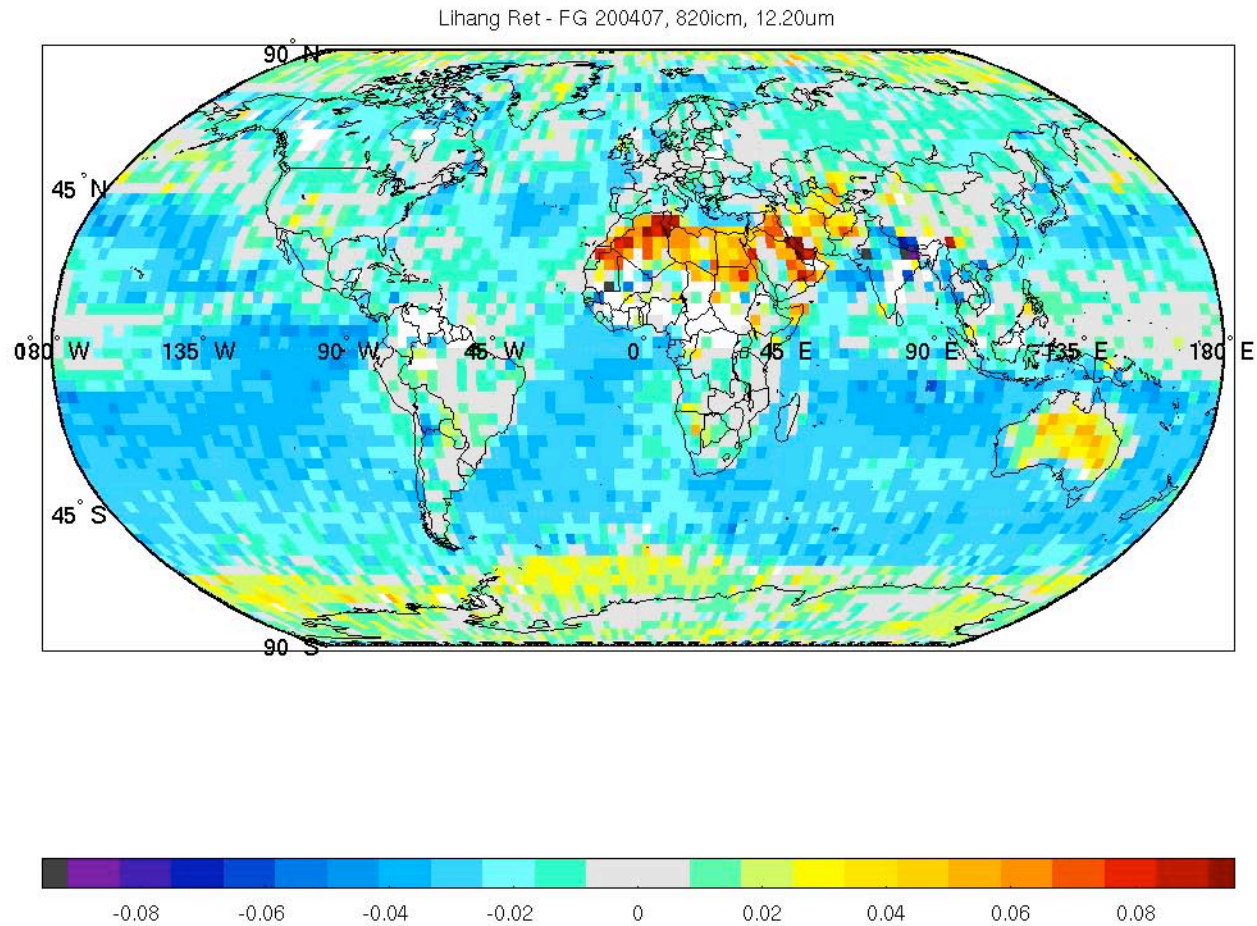


# Barnet Physical Retrieval

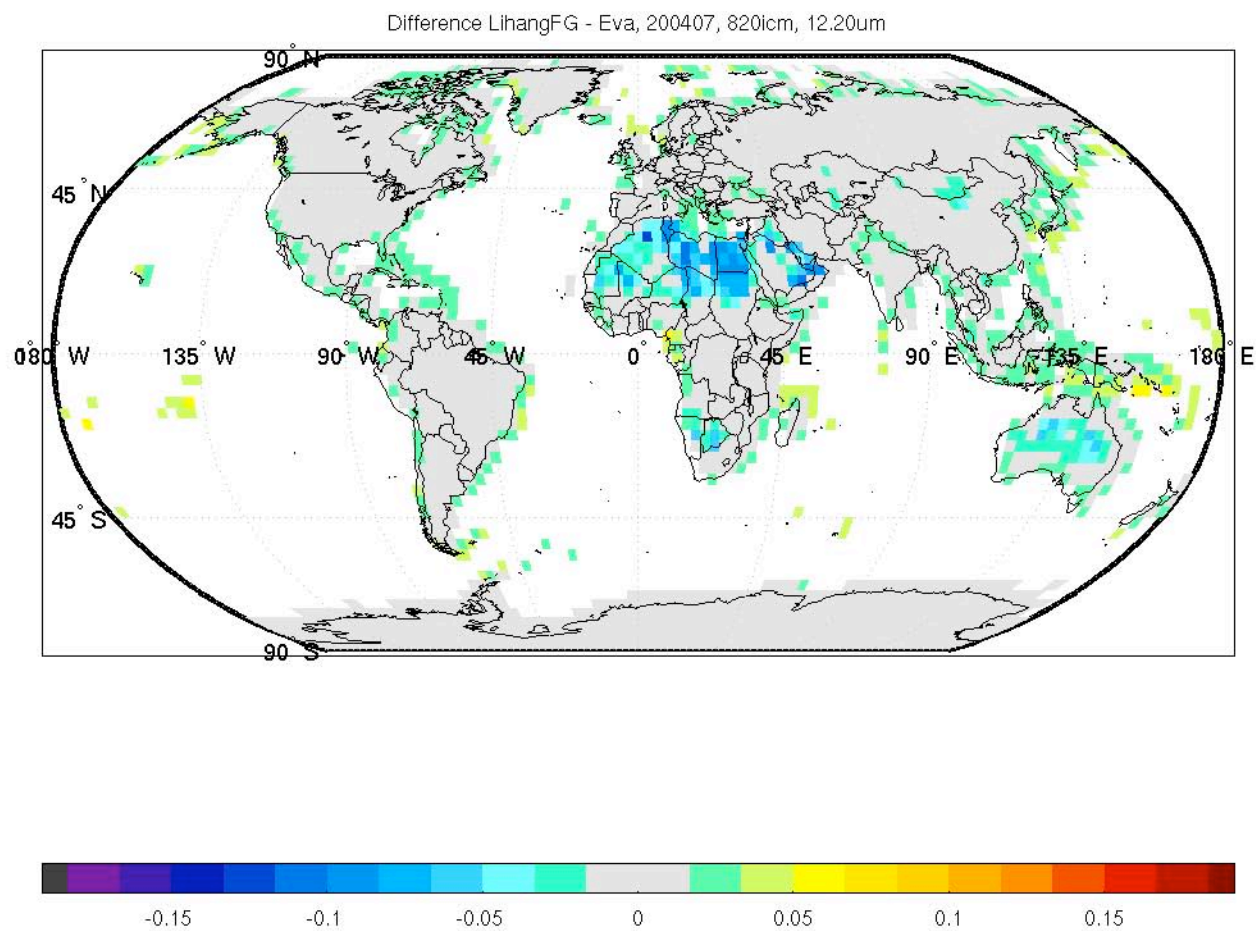
## $12.2\text{ }\mu\text{m}$ ( $820\text{ cm}^{-1}$ )



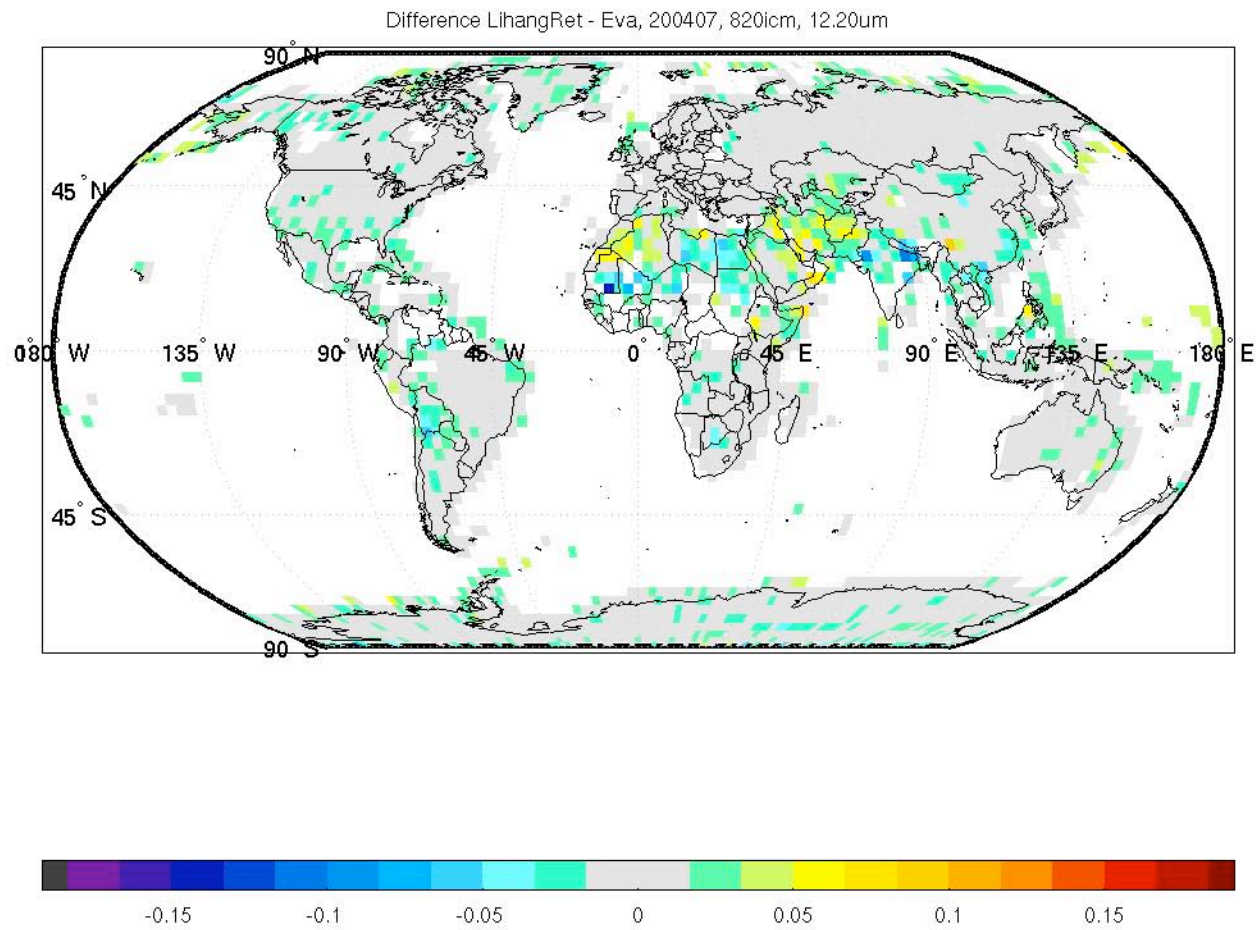
# Lihang ret - fg, 12.2um



## Lihang Fg - S&B, 12.2um



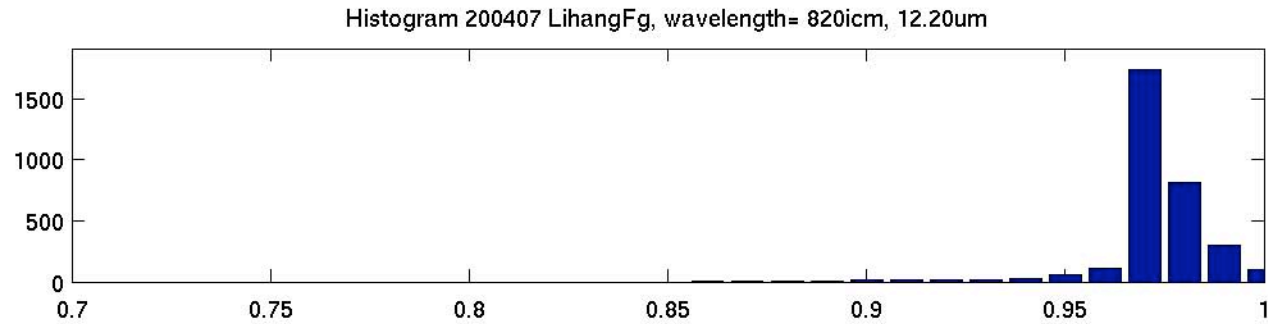
## Lihang Ret - S&B, 12.2um



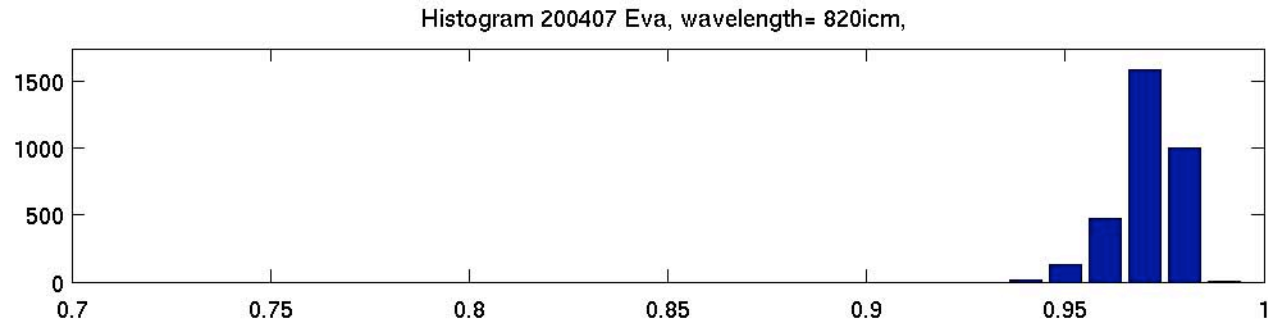


# Lihang Regression, 12.2um

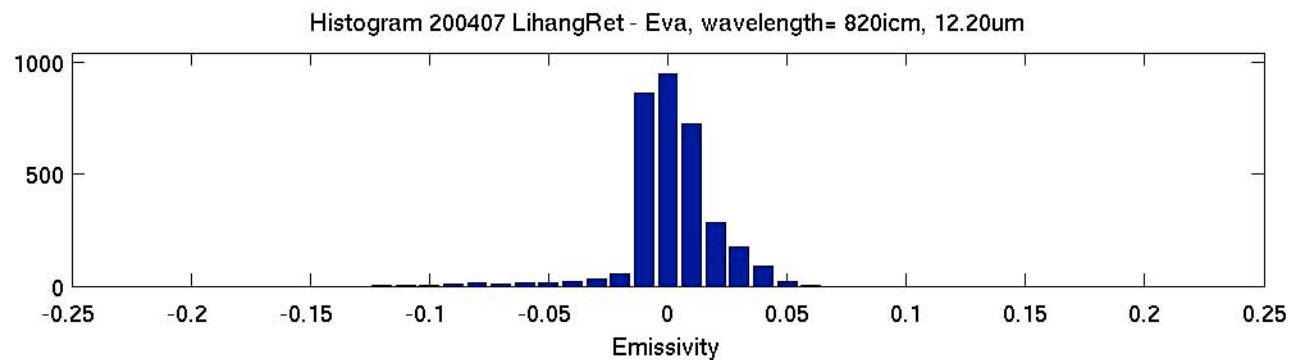
AIRS



MODIS

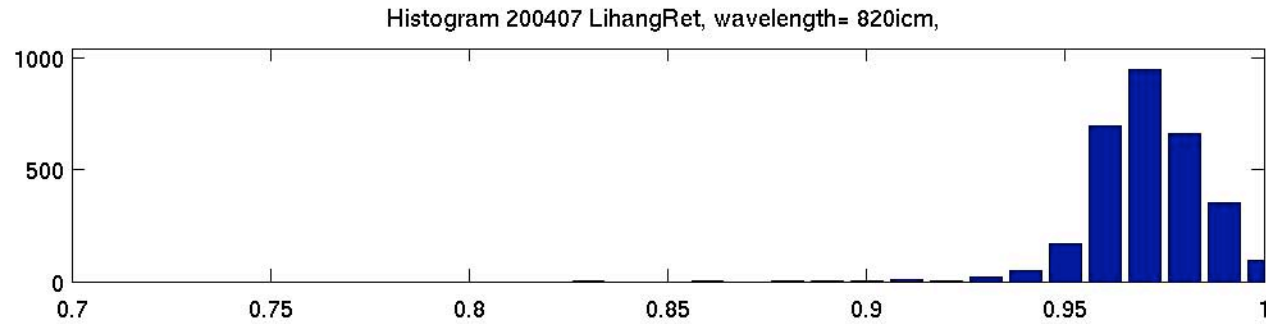


AIRS  
Minus  
MODIS

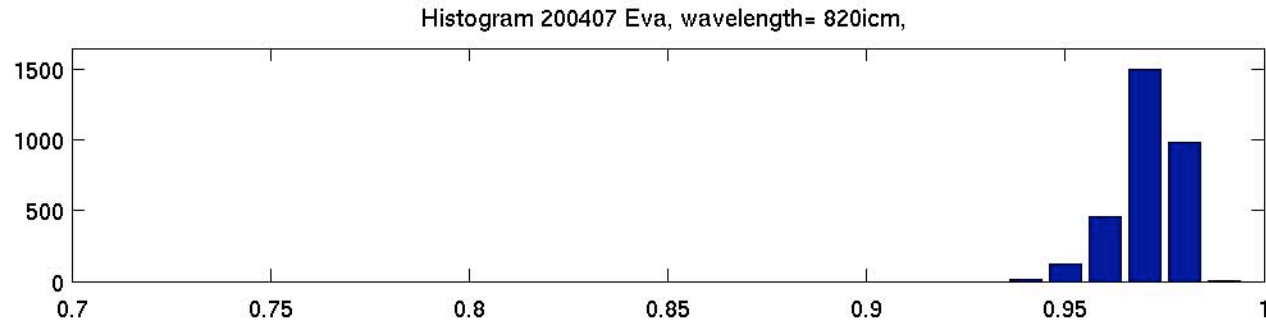


# Barnet Physical, 12.2um

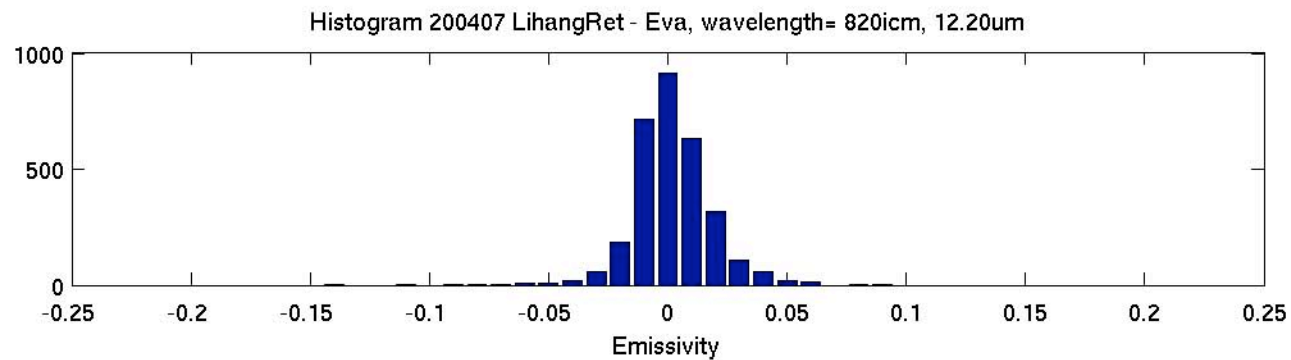
AIRS



MODIS

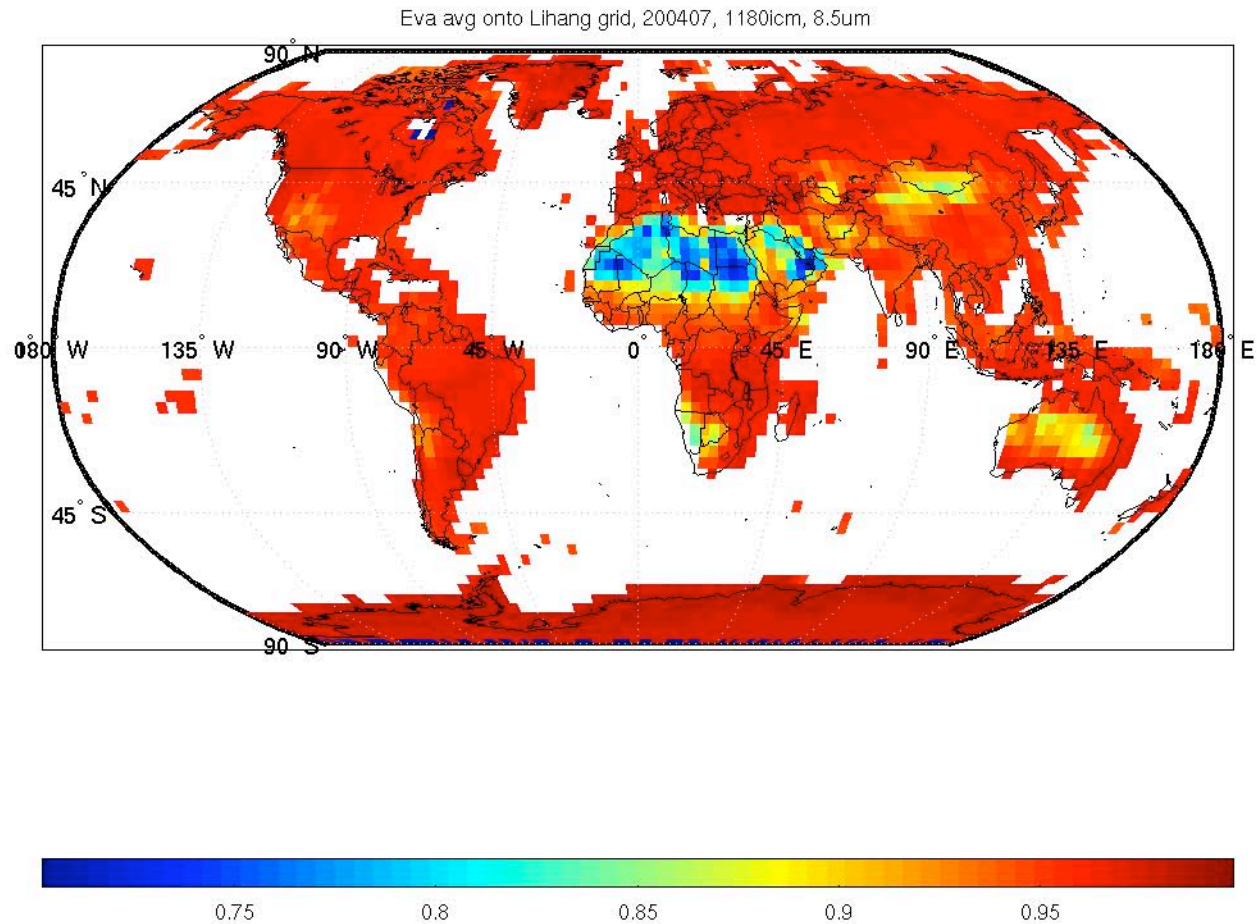


AIRS  
Minus  
MODIS



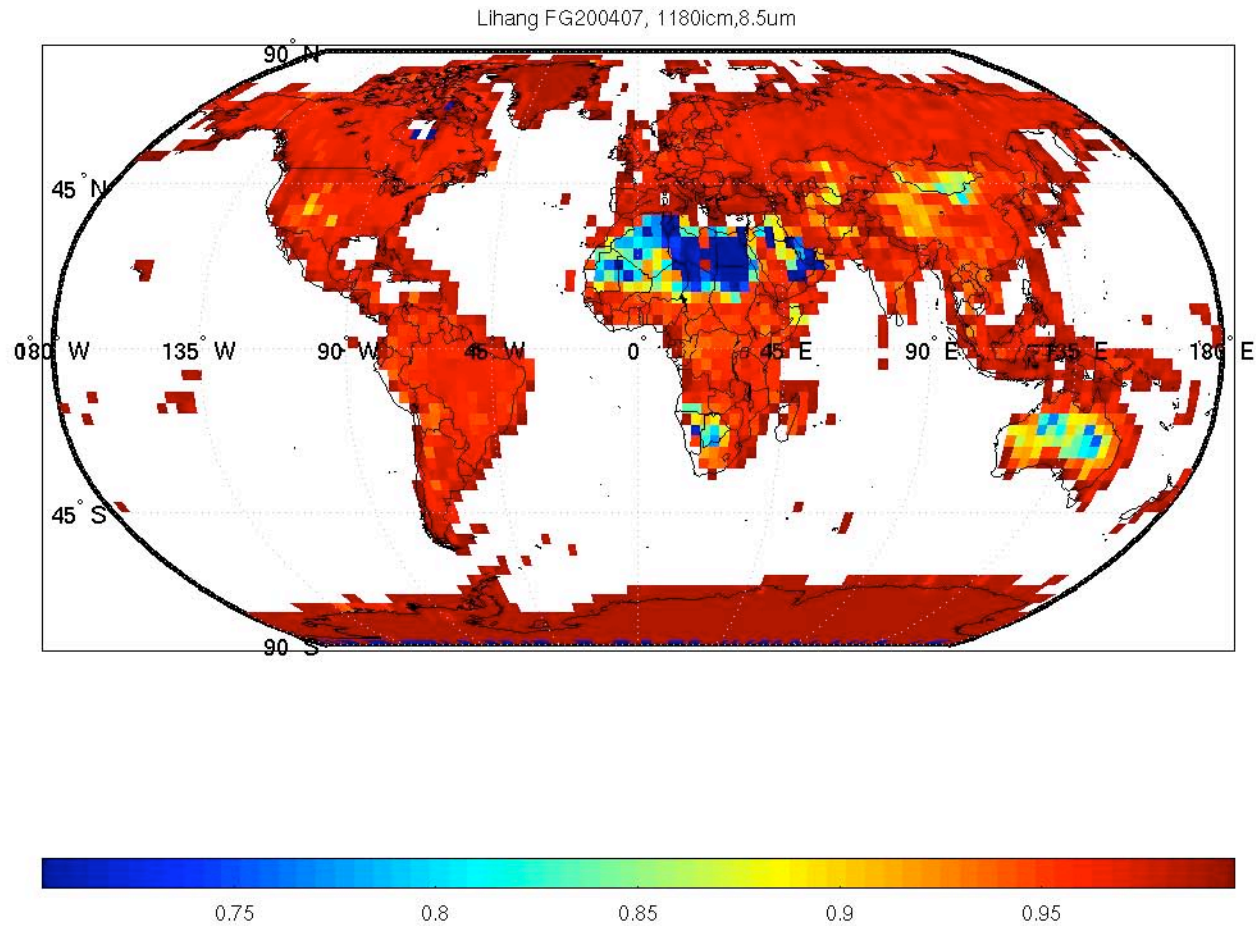
# UW/MODIS (Seeman/Borbias/Wan)

## $8.5\text{ }\mu\text{m}$ ( $1180\text{ cm}^{-1}$ )



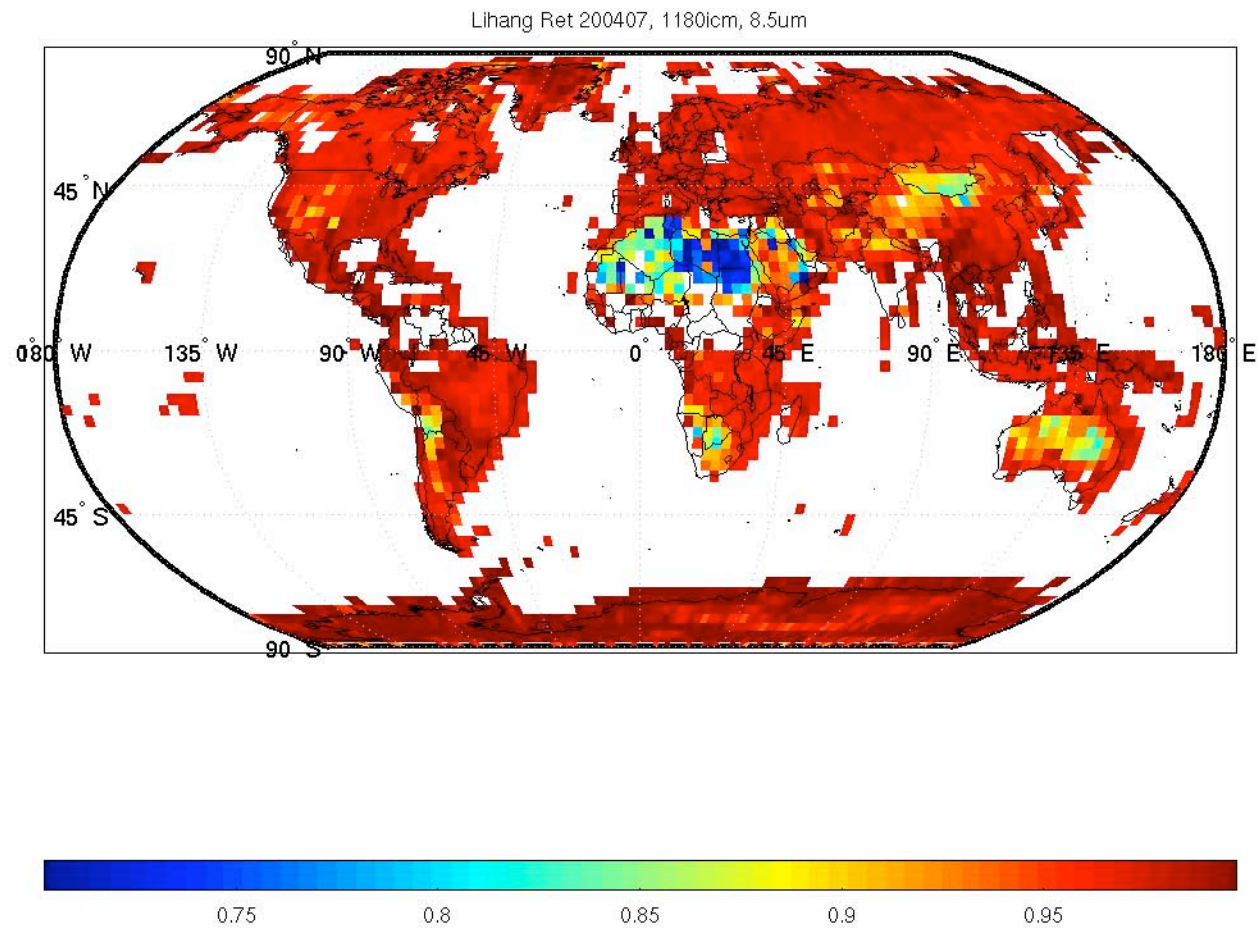
# Lihang Regression

## $8.5\text{ }\mu\text{m}$ ( $1180\text{ cm}^{-1}$ )



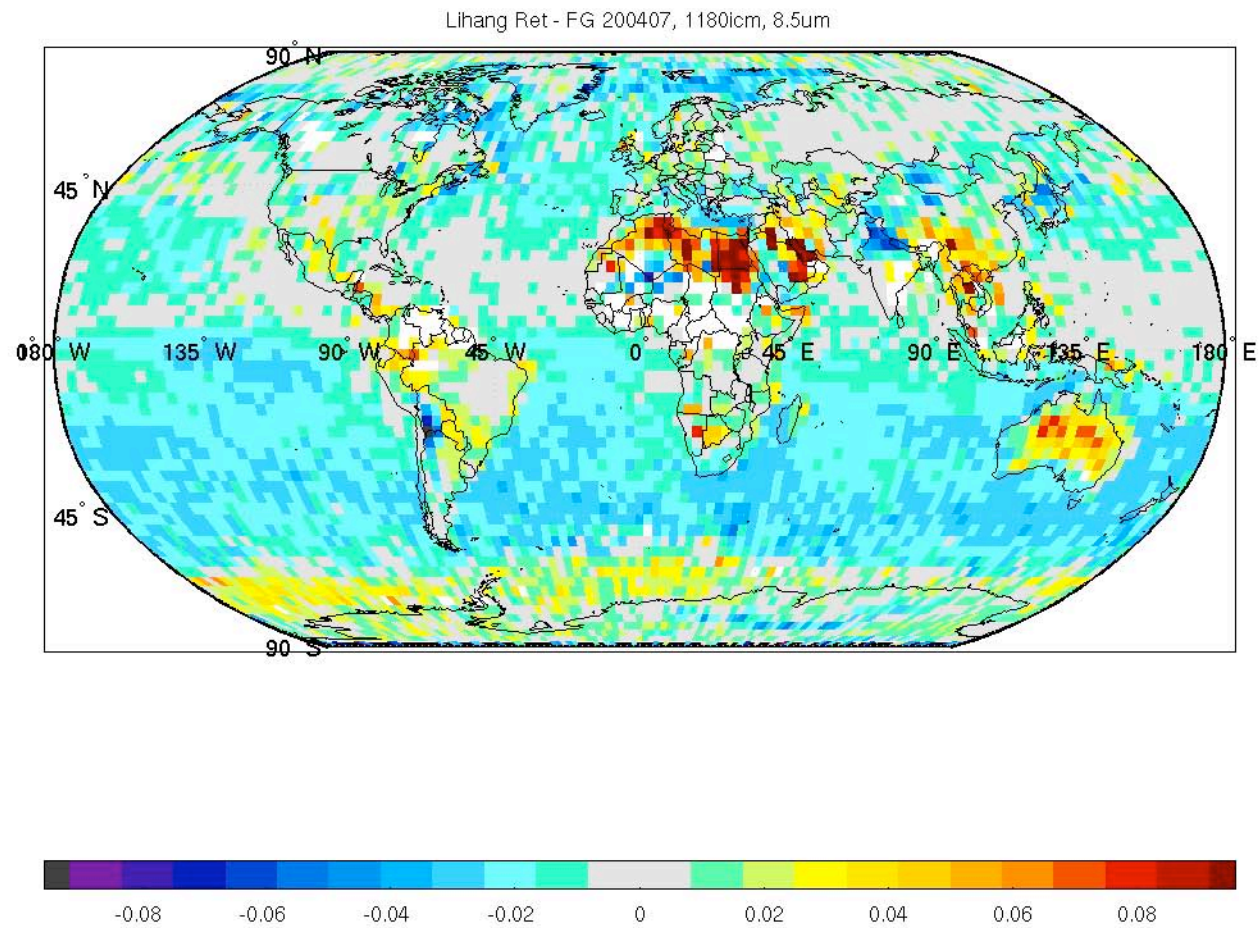
# Barnet Physical

## $8.5\text{ }\mu\text{m}$ ( $1180\text{ cm}^{-1}$ )

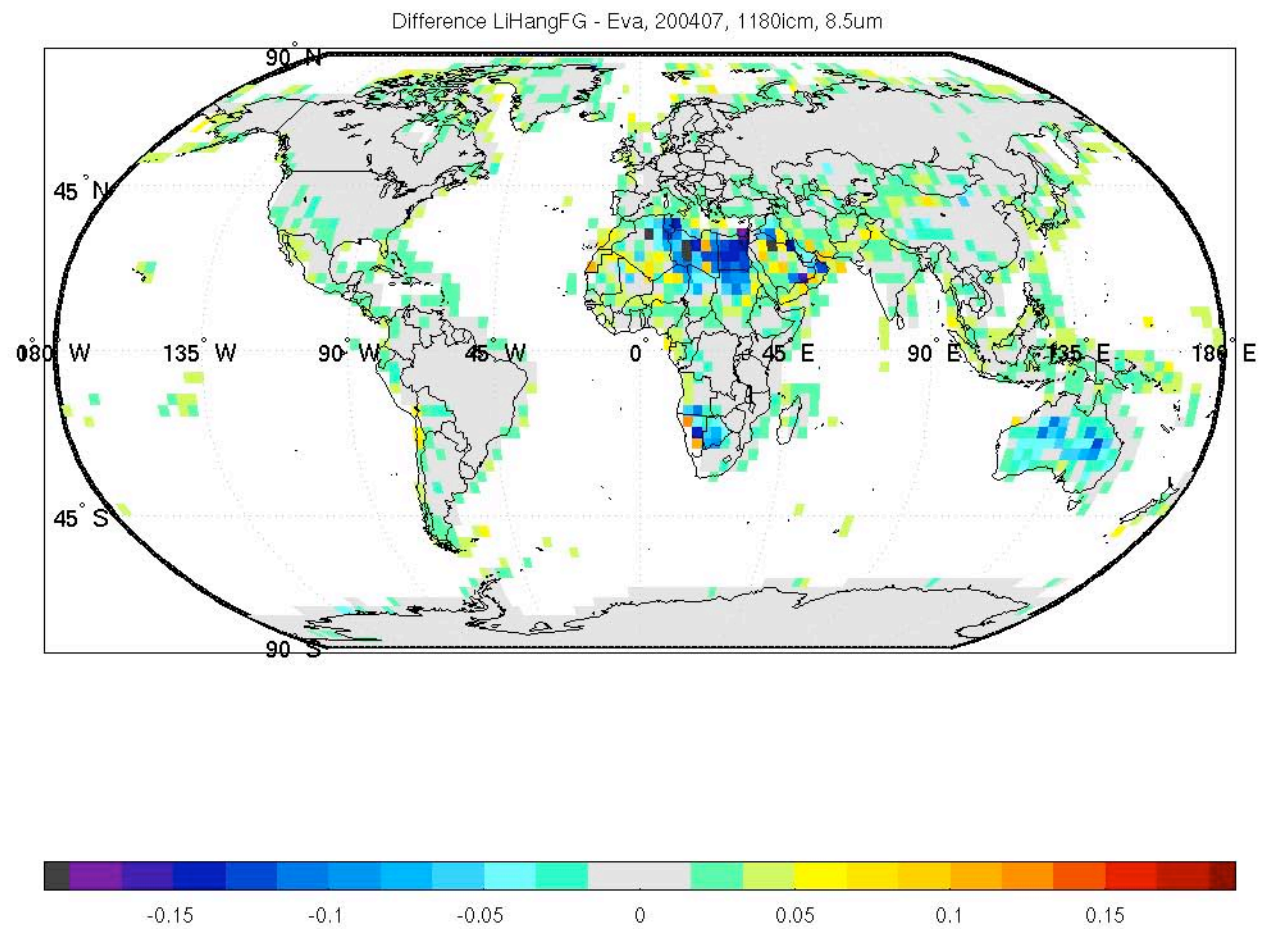




## Lihang ret - fg, 8.5um

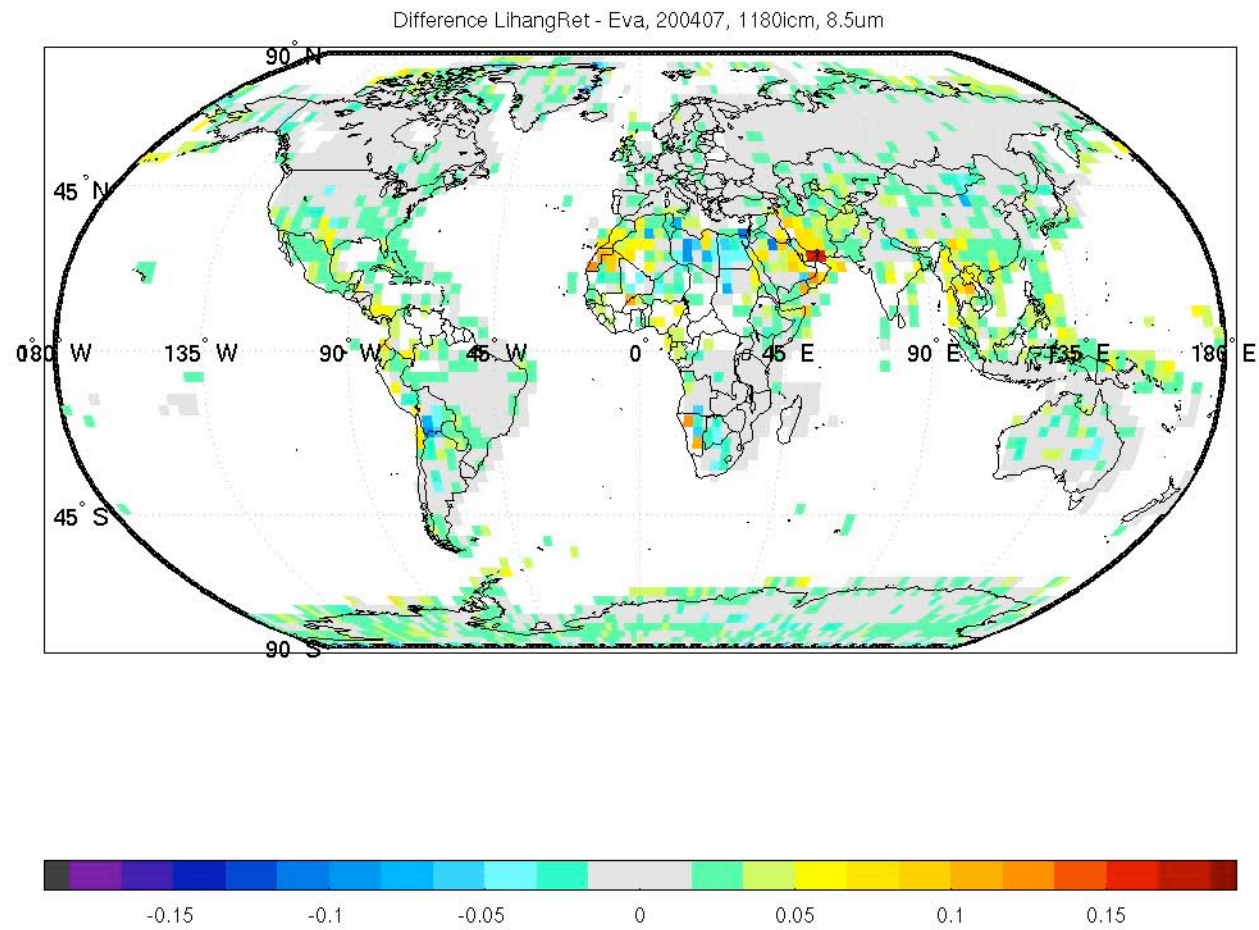


## Lihang Fg - S&B, 8.5um



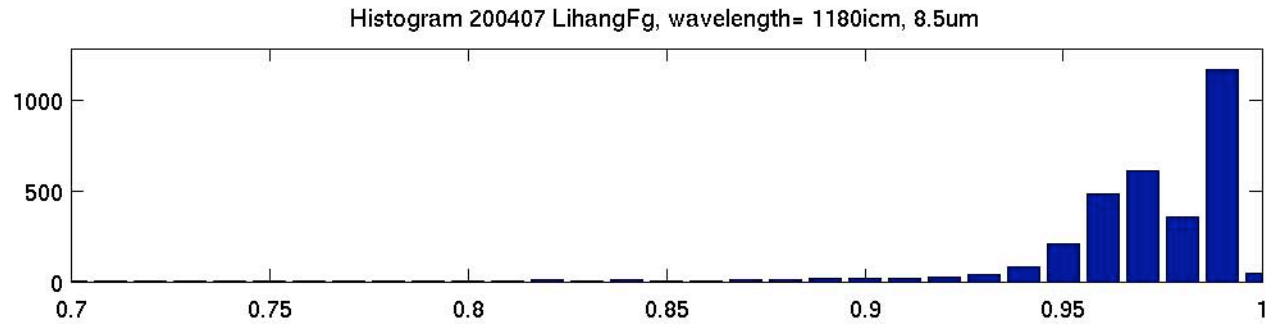


## Lihang Ret - S&B, 8.5um

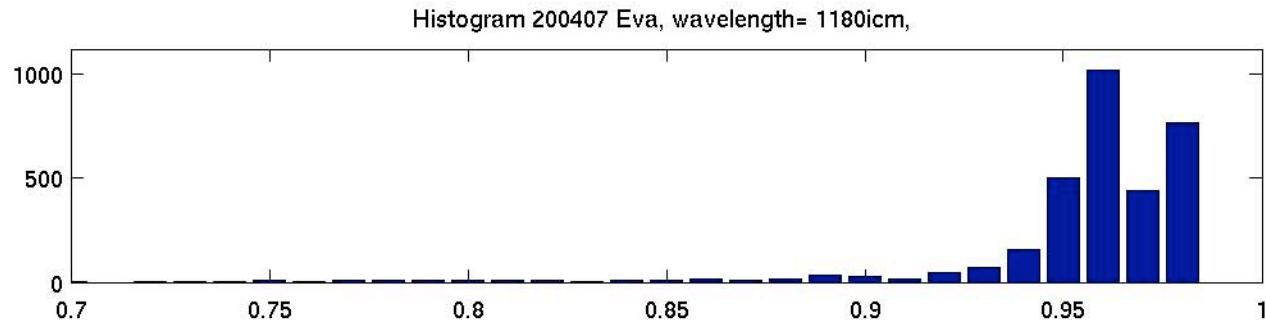


# Lihang Regression, 8.5um

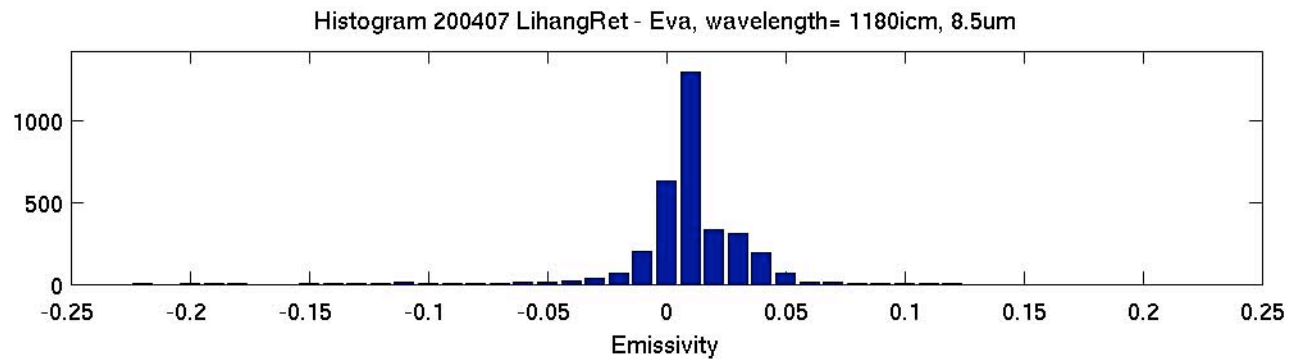
AIRS



MODIS

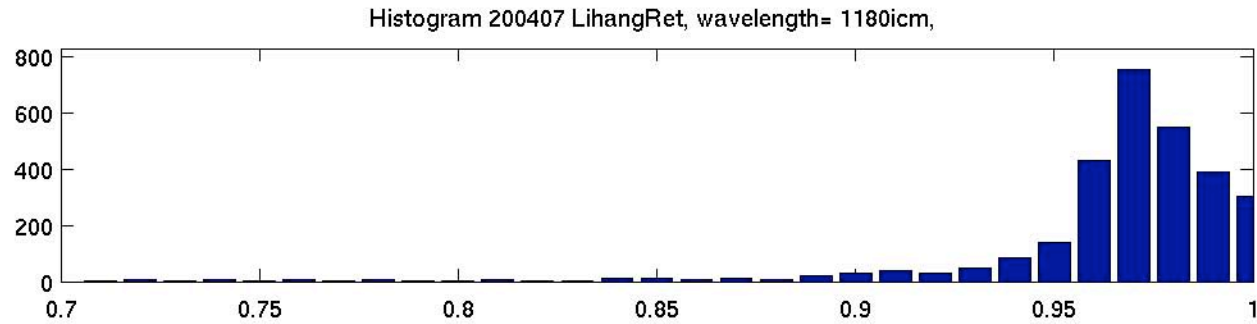


AIRS  
Minus  
MODIS

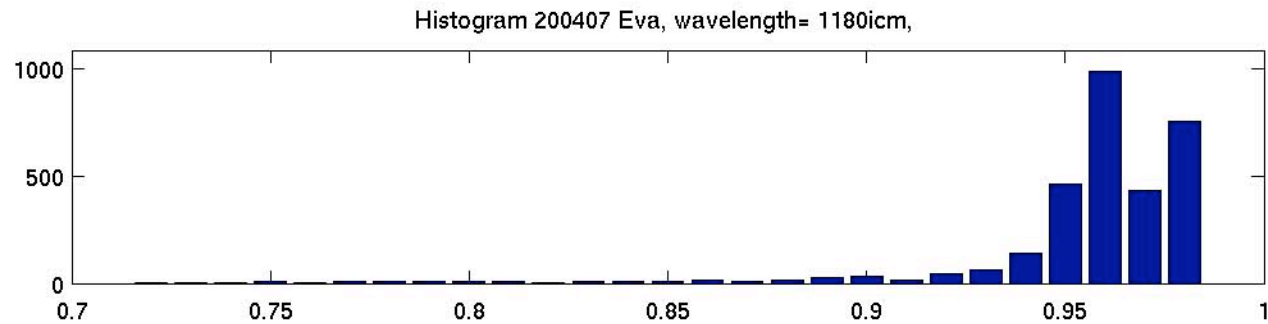


# Barnet Physical, 8.5um

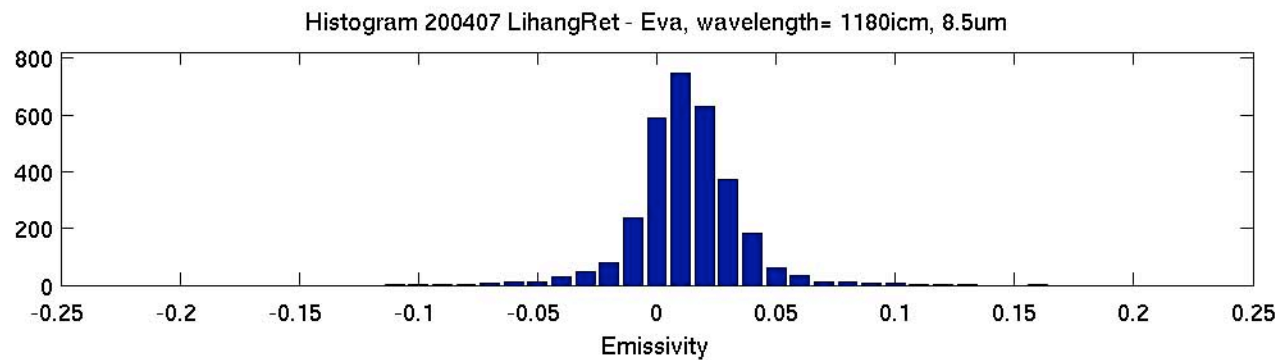
AIRS



MODIS

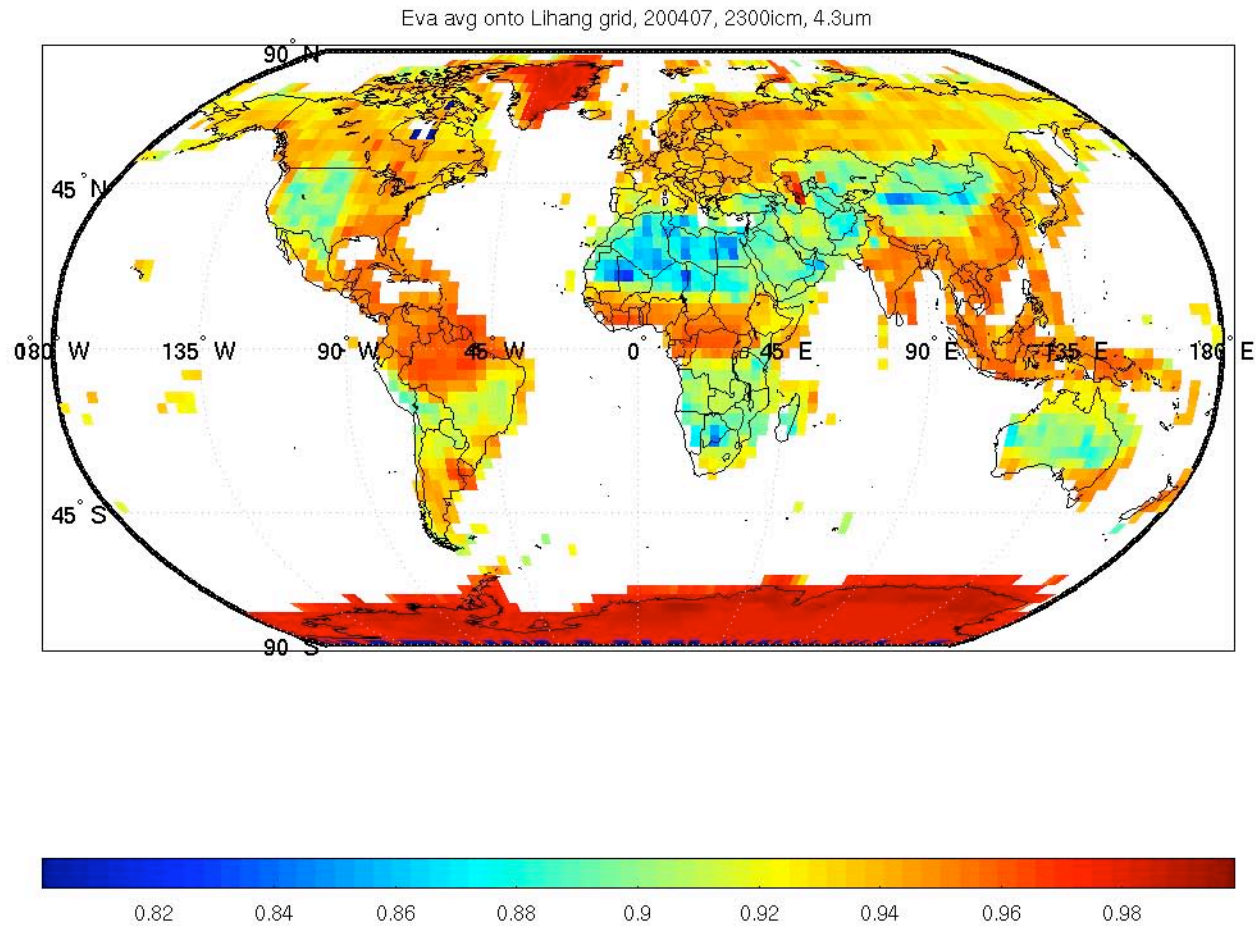


AIRS  
Minus  
MODIS



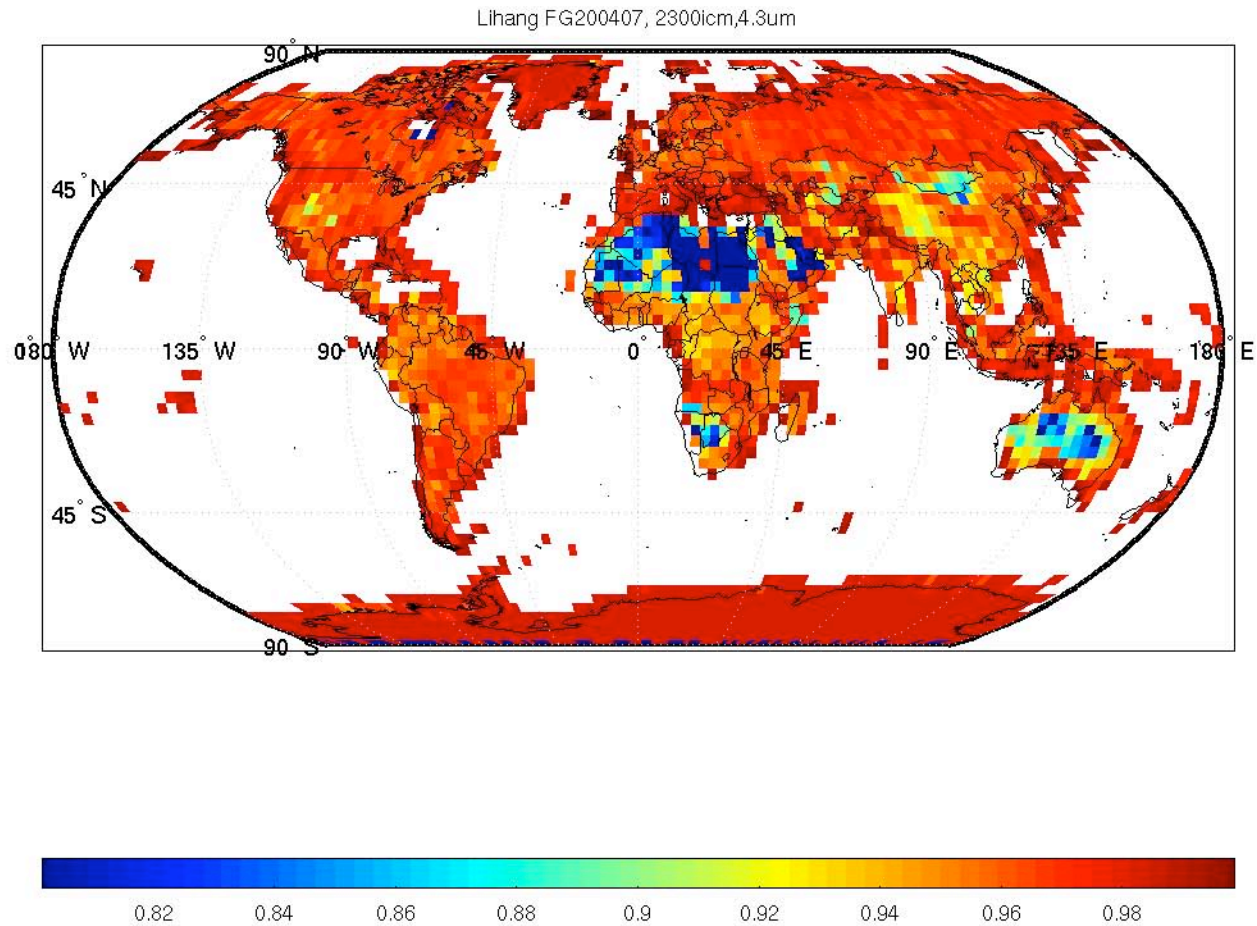
# UW/MODIS (Seeman/Borbias/Wan)

## $4.34\text{ }\mu\text{m}$ ( $2300\text{ cm}^{-1}$ )



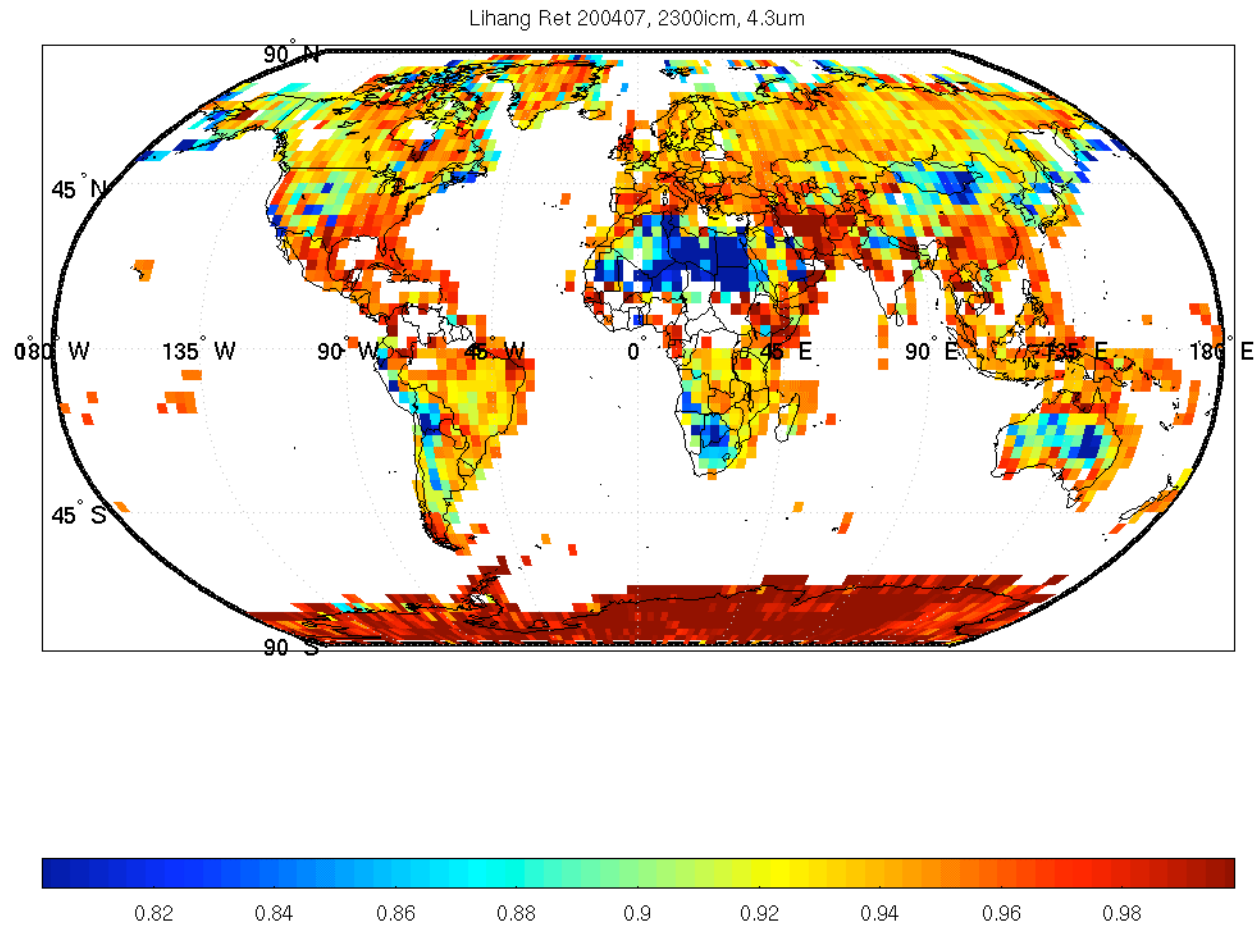
# Lihang Regression

$4.34\text{ }\mu\text{m}$  ( $2300\text{ cm}^{-1}$ )



# Barnet Physical

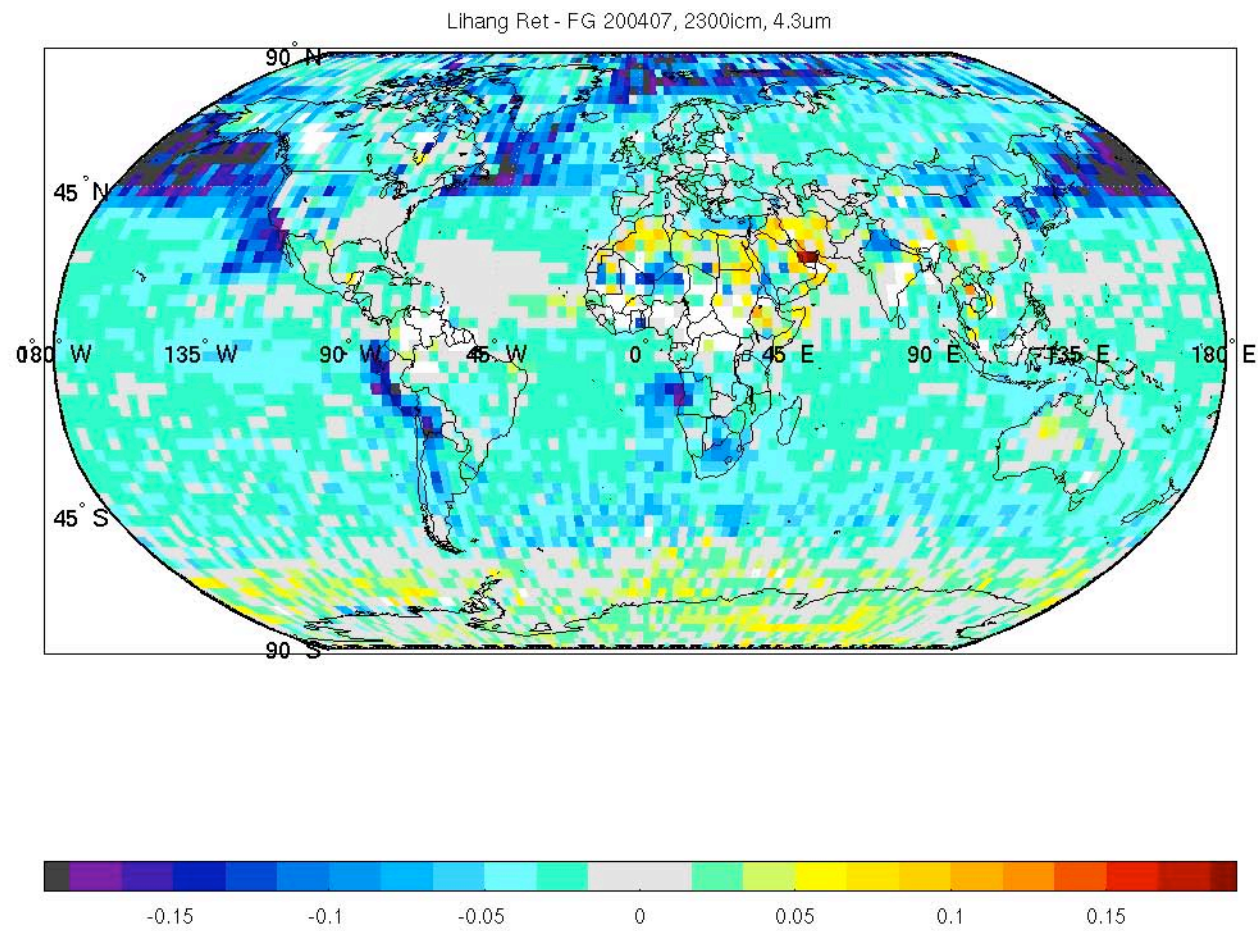
## $4.34\text{ }\mu\text{m}$ ( $2300\text{ cm}^{-1}$ )



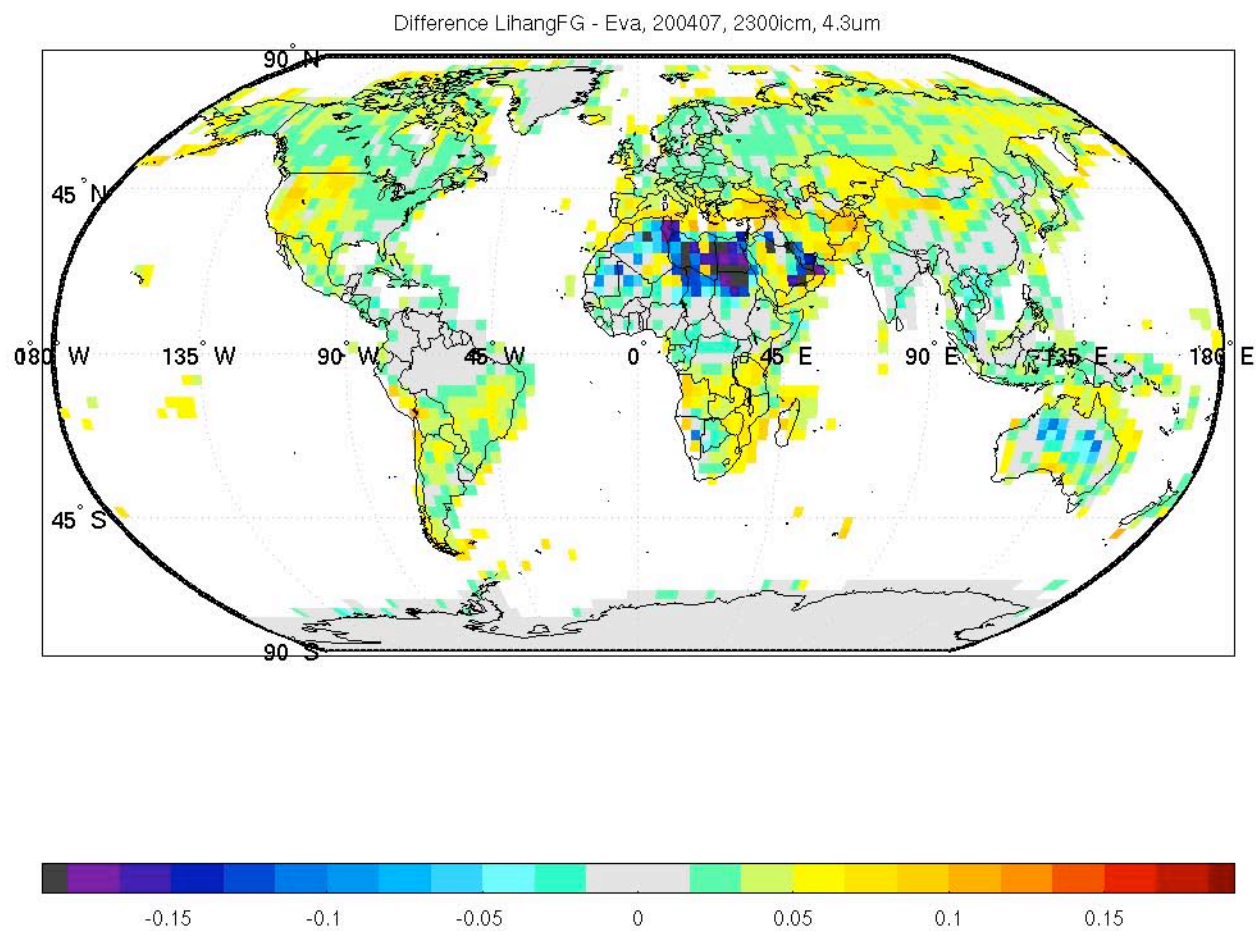
No Result Available from  
Joel's SW Retrieval yet.



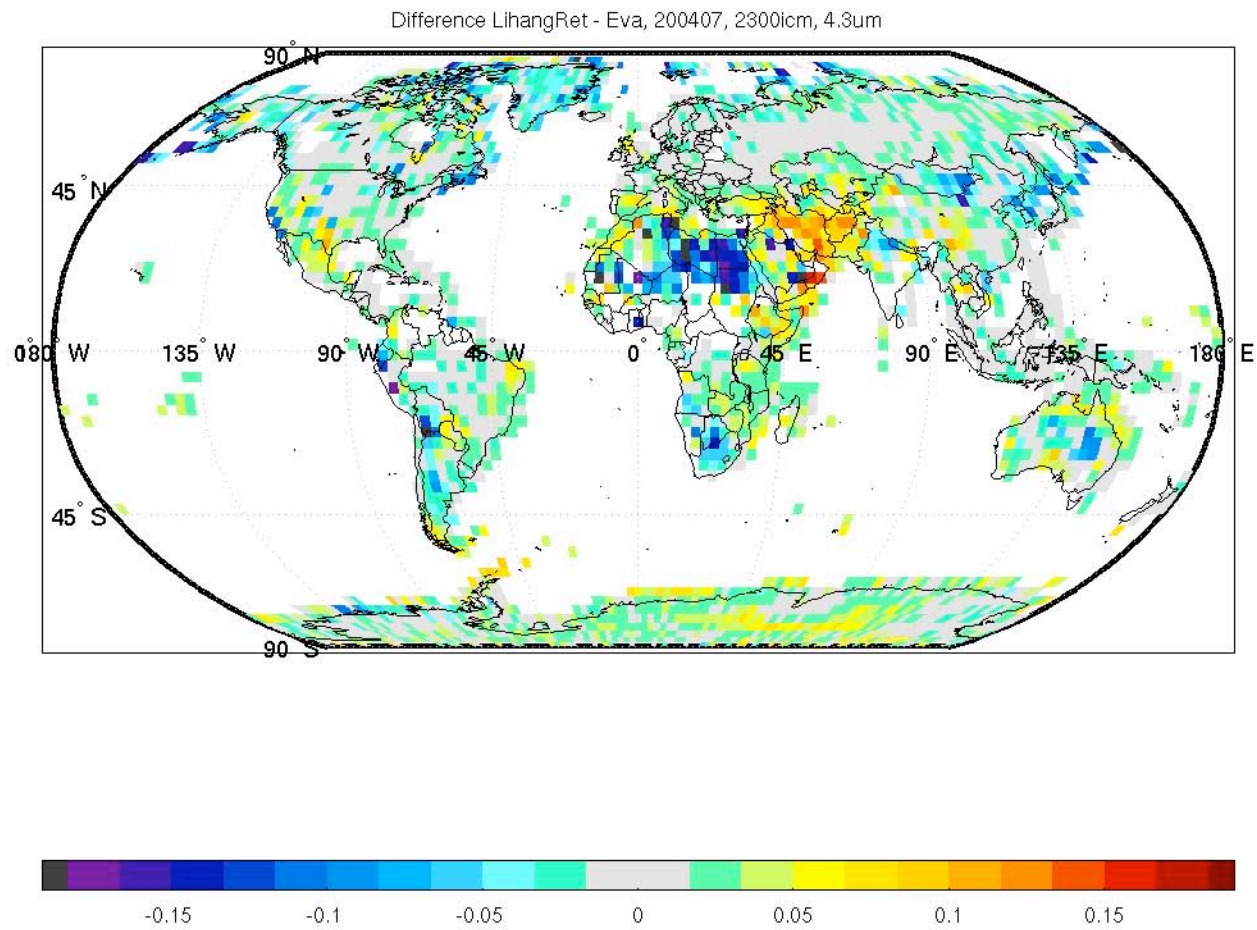
## Lihang ret - fg, 4.34um



## Lihang Fg - S&B, 4.34um

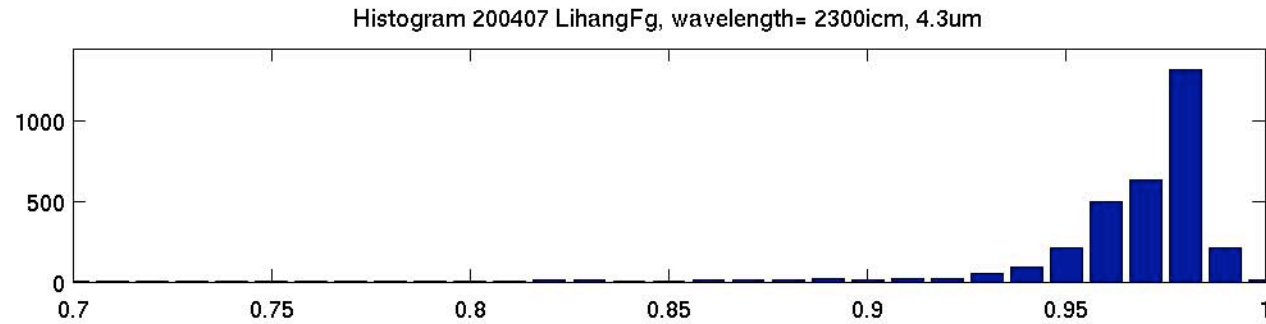


## Lihang Ret - S&B, 4.34um

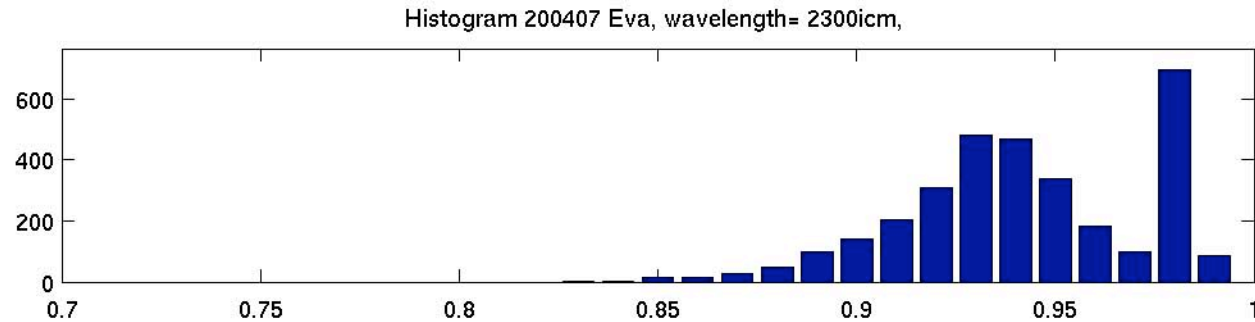


# Lihang Regression, 4.34um

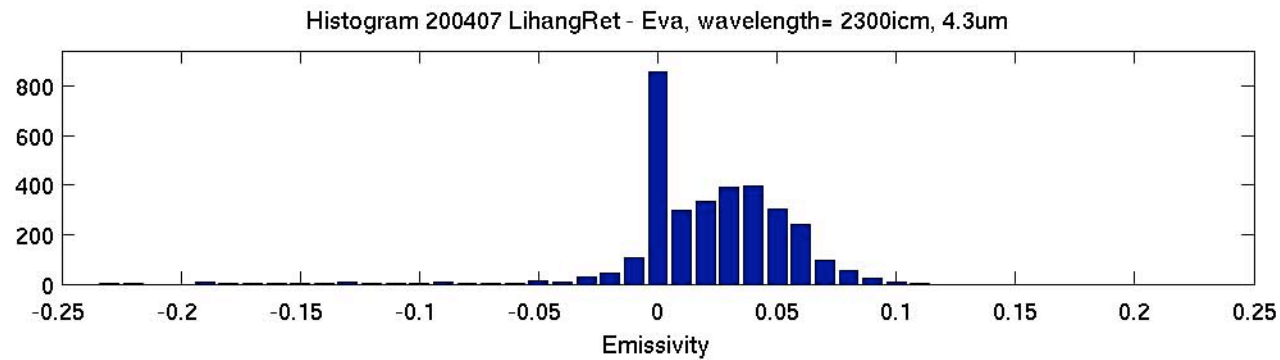
AIRS



MODIS

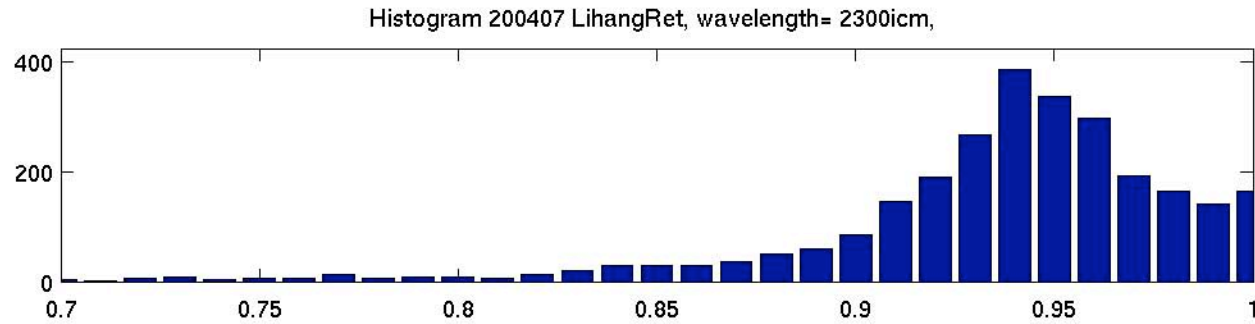


AIRS  
Minus  
MODIS

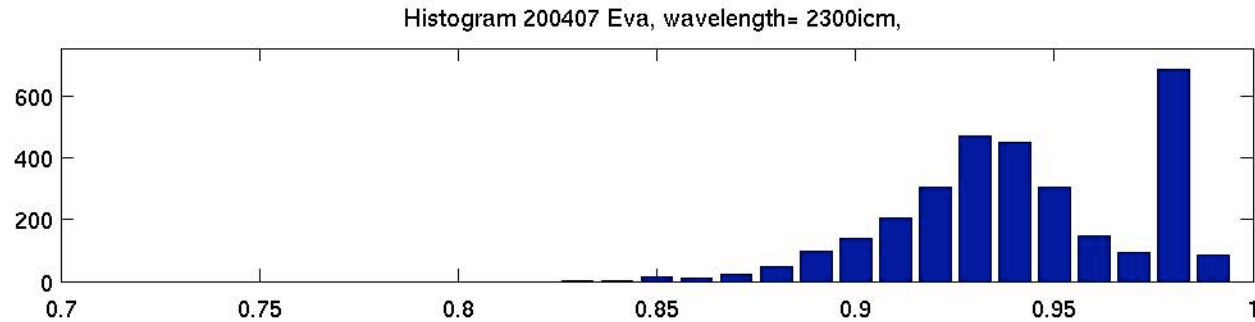


# Barnet Physical, 4.34um

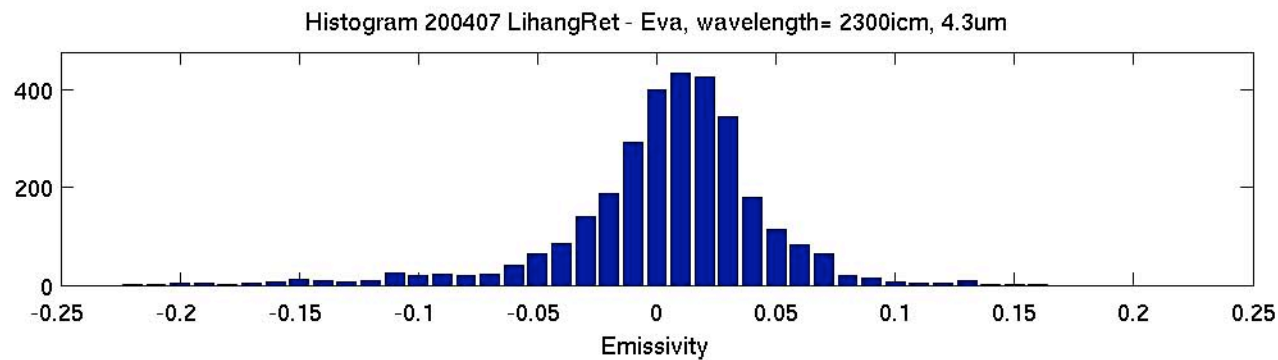
AIRS



MODIS



AIRS  
Minus  
MODIS





# PGE Version 5

## (Preliminary Conclusions)

1. The AIRS (Barnet) physical retrieval of emissivity is significantly improved over the regression emissivity in both the longwave and shortwave infrared window regions.
2. However, my understanding is that there will not be a physical retrieval of emissivity in the longwave so that the regression results will be used as final. This is a less than optimal product in the longwave.
3. Moreover, the shortwave emissivity will be retrieved by Joel Susskind's algorithm (not the same as Chris Barnet's) but Joel's emissivity output has not yet been evaluated. (We should try to do this soon.)
4. Note to JPL Integration Team: It would have been nice to be able to evaluate products like this before the PGE Version 5 was frozen so we could optimize the algorithms.

## Recommendations for the next PGE Version (V. 6)

1. Take advantage of the validation data collected over the past four years to guide the selection of algorithm improvements. This provides an objective measure of improvements that is independent of ECMWF or NCEP model comparisons.
2. Use the global network of surface radiation sites around the world (including ARM) for AIRS land temperature validation as multi-year time series to look for seasonal biases.



## Recommendations for the next PGE Version (V. 6)

3. Use the UW/MODIS Seeman/Borbas/Wan emissivity database (using laboratory data combined with MODIS as a reference for comparison of AIRS results. The ASTER emissivity atlas provides another valuable reference for comparison.
4. Demonstrate that Version 6 suggested algorithm changes are an improvement over version 5 earlier in the development cycle. (Reprocess the matchup dataset!!!)

# Project Description

- **Land Surface Characterization Using High Spectral Resolution AIRS and Moderate Spatial Resolution MODIS Observations from the EOS Aqua Platform**
- R. Knuteson - PI
- NASA Aqua Validation
- Funded by NASA Terrestrial Ecosystems
- Three year grant (one year remaining)
- Themes:
  - (1) Improve the use of sounder data over land.
  - (2) Assess land surface changes in regions sensitive to climate variations, e.g. semi-arid.